

DRAFT FINAL RCRA FACILITY INVESTIGATION ADDENDUM REPORT FOR SOLID WASTE MANAGEMENT UNIT 28

TOOELE ARMY DEPOT - SOUTH Stockton, Utah

Prepared for:
U.S. Army Corps of Engineers, Sacramento District,
Tooele Army Depot - South,
and U.S. Army Environmental Command



Contract Number: W91238-06-D-0016
Delivery Order: 0010

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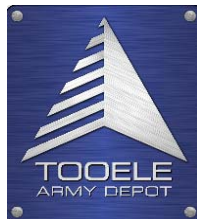
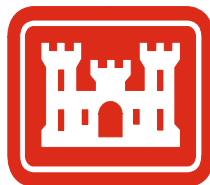
February 2014

**DRAFT FINAL
RCRA FACILITY INVESTIGATION ADDENDUM
REPORT FOR SOLID WASTE MANAGEMENT UNIT 28
AT TOOEELE ARMY DEPOT – SOUTH AREA
STOCKTON, UTAH**

Prepared For:

DEPARTMENT OF THE ARMY
SACRAMENTO DISTRICT, CORPS OF ENGINEERS,
TOOELE ARMY DEPOT - SOUTH,
and
U.S. ARMY ENVIRONMENTAL COMMAND

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ACRONYMS AND ABBREVIATIONS

%D	Percent Difference
4-BFB	4-Bromofluorobenzene
amsl	Above Mean Sea Level
AUF	Area Use Factor
bgs	Below Ground Surface
BRAC	Base Realignment and Closure
CAP	Corrective Action Program
CBDCOM	Chemical Biological Defense Command
CCV	Continuing Calibration
CMI	Corrective Measures Implementation
CMS	Corrective Measures Study
CSM	Conceptual Site Model
COPC	Chemical of Potential Concern
COPEC	Chemical of Potential Ecological Concern
CWM	Chemical Warfare Materiel
DAF	Dilution Attenuation Factor
DCD	Deseret Chemical Depot
DoD	Department of Defense
DSHW	Division of Solid and Hazardous Waste
DVR	Data Validation Report
ELAP	Environmental Laboratory Accreditation Program
EM	Engineering Manual
EPC	Exposure Point Concentration
ERA	Ecological Risk Assessment
eV	Electron Volt
°F	Degrees Fahrenheit
ft	Foot/Feet
GPS	Global Positioning System
H5N95	95-percent Nitrogen
HI	Hazard Index
HQ	Hazard Quotient
HRA	Human Health Risk Assessment
ICP	Inductively Coupled Plasma
ICV	Initial Calibration Verification

ACRONYMS AND ABBREVIATIONS (CONTINUED)

IDW	Investigation Derived Waste
LCS	Laboratory Control Sample
LCSD	Laboratory Control Sample Duplicate
LOAEL	Lowest-Observed-Adverse-Effect-Level
LOD	Limit of Detection
LOQ	Limit of Quantitation
µg/L	Micrograms per Liter
µg/m ³	Micrograms per Cubic Meter
MCL	Maximum Contaminant Level
MEK	Methyl Ethyl Ketone
mg/kg	Milligrams per Kilogram
MS	Matrix Spike
MSD	Matrix Spike Duplicate
ND	Non-Detect
NELAP	National Environmental Laboratory Accreditation Program
NFA	No Further Action
NOAEL	No-Observed-Adverse-Effect-Level
PAH	Polycyclic Aromatic Hydrocarbon
PA/SI	Preliminary Assessment/Site Investigation
PDS	Post Digestion Spike
PEF	Particulate Emission Factor
PID	Photoionization Detector
ppm	Parts per Million
PPRTV	Provisional Peer Reviewed Toxicity Value
PTFE	Polytetrafluoroethylene
PWS	Performance Work Statement
QA	Quality Assurance
QAPjP	Quality Assurance Project Plan
QC	Quality Control
QSM	Quality Systems Manual
RAD	Risk Assumptions Document
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facility Assessment
RFI	RCRA Facility Investigation

ACRONYMS AND ABBREVIATIONS (CONTINUED)

RPD	Relative Percent Difference
RSL	Regional Screening Level
SDG	Sample Delivery Group
SLHQ	Screening-Level Hazard Quotients
SOP	Standard Operating Procedure
SSL	Soil Screening Level
SVOC	Semi-Volatile Organic Compound
SWMU	Solid Waste Management Unit
TCE	Trichloroethylene
TCLP	Toxicity Characteristic Leaching Procedure
TEAD-S	Tooele Army Depot - South Area
TOCDF	Tooele Chemical Agent Disposal Facility
TRV	Toxicity Reference Value
UAC	Utah Administrative Code
UCL	Upper Confidence Limit
UDEQ	Utah Department of Environmental Quality
U.S.	United States
USACE	United States Army Corps of Engineers
USAEC	U.S. Army Environmental Command
USDOT	U.S. Department of Transportation
USEPA	U.S. Environmental Protection Agency
UXO	Unexploded Ordnance
VF	Volatilization Factor
VI	Vapor Intrusion
VMP	Vapor Monitoring Point
VOC	Volatile Organic Compound

EXECUTIVE SUMMARY

This Resource Conservation and Recovery Act (RCRA) Facility Investigation (RFI) Addendum report details the recent investigation activities conducted at Tooele Army Depot - South Area (TEAD-S) Solid Waste Management Unit (SWMU) 28 in Tooele County, Utah. SWMU 28 is an inactive (abandoned) landfill encompassing approximately 0.3 acres, located approximately 1,000 feet (ft) southwest of the TEAD-S Administrative Area.

Previous investigations at SWMU 28 were limited to the installation and sampling of three groundwater monitoring wells. Periodic sampling of these wells over the last 20 years has shown no impacts to site groundwater. Soil and soil gas have not been investigated at the site previously and therefore, additional sampling was warranted at SWMU 28. The primary objectives of the RFI Addendum were to characterize the nature and extent of contamination within the landfill and determine if contaminants have been released to the environment which pose a risk to human and ecological receptors. To achieve these objectives, the following investigation activities were conducted at SWMU 28:

- Thirty surface soil samples were collected;
- Fourteen soil gas samples were collected from seven collocated shallow and deep vapor monitoring points (VMPs); and
- Seven direct push soil borings were advanced to 25 ft below ground surface (bgs), with subsurface samples collected at five-foot intervals;

A total of 30 surface soil samples (i.e., 0-0.5 ft bgs) and three field duplicates were collected at the landfill and analyzed for semi-volatile organic compounds (SVOCs), explosives, and metals. No explosives were detected in any of the surface soil samples collected at SWMU 28. Only benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene had maximum detected concentrations in surface soil that were greater than their corresponding USEPA (2013a) residential soil RSLs. PAHs are both naturally occurring and anthropogenic, and they are ubiquitous in the environment. Nearby sources of PAHs (e.g., wind-blown dust, burned grass, and asphalt used for roads and parking areas) represent the most likely source for the trace detections of PAHs in SWMU 28 surface soils. Fourteen active soil gas samples and two field duplicates were collected from seven collocated shallow (5 ft bgs) and deep (12 ft bgs) vapor monitoring points at SWMU 28. The maximum detected concentrations in soil gas were

1 primarily detected in the western portion of the site at sample SG-28-01. With the exception of
2 acetone and 1,3,5-trimethylbenzene, all maximum soil gas concentrations were detected in the
3 deeper sample interval (12 ft bgs). Based on the deeper nature of the soil gas detections, further
4 evaluation of subsurface soils was necessary to assess the nature and extent of contamination at
5 SWMU 28. A total of 35 subsurface soil samples and four field duplicates were collected from
6 seven soil borings at SWMU 28 and analyzed for volatile organic compounds (VOCs), SVOCs,
7 and metals. None of the detected analytes exceeded their respective residential soil Regional
8 Screening Level (RSL). Based on field observations made during soil boring activities, landfill
9 debris is present between 3.5 to 14 ft bgs. Buried debris was largely municipal, construction, and
10 household wastes including foam padding, plastic sheeting, metal straps, empty containers,
11 pieces of wood, and rubber tire remnants. Buried debris is present to a maximum depth of
12 approximately 11 to 14 ft bgs. Native soils were encountered below the landfill debris zone, at
13 approximately 12 to 15 ft bgs.

14 A risk assessment was conducted using residential (hypothetical) and industrial (actual)
15 land use exposure scenarios to determine potential risks and hazards to receptors from exposure
16 to contaminants at SWMU 28. The carcinogenic risks estimated for residents exceed the point of
17 departure of 1×10^{-6} . This risk estimate is almost entirely due to assumed exposures to
18 benzo(a)pyrene in soils and assumed inhalation exposures to chloroform in indoor air from soil
19 gas. However, the risk estimates for industrial and construction workers are within the USEPA
20 (1990) risk management range of 10^{-6} to 10^{-4} . The noncarcinogenic HI estimated for residents,
21 industrial workers, and construction workers are less than or equal to 1.0, the benchmark level of
22 concern for noncarcinogenic effects. An ecological risk assessment was also conducted and no
23 chemicals of concern were identified that may pose potential hazards to populations of
24 ecological receptors at the site. Soil-to-groundwater analysis also indicates that future impacts to
25 groundwater from chemicals of potential concern (COPCs) in soil are not expected. Therefore,
26 based on the results from the soil-to-groundwater evaluation, detections in soils are not present at
27 concentrations that will significantly impact groundwater in the future and degradation of natural
28 resources is not likely.

29 SWMU 28 does not qualify for no further action (NFA) or risk-based closure under the
30 requirements of Utah Administrative Code (UAC) R315-101-6, since residential cumulative
31 cancer risk and noncancer HI estimates exceeded residential target levels. However, risks and

1 hazards associated with exposures to soil and soil gas are below industrial target levels that
2 require corrective action. Therefore, based on the results of the investigation, the following
3 measures are recommended for the SWMU 28 site:

- 4 • Corrective action is not required for the site and industrial closure with post-closure
5 care is recommended. Future property development should be limited to industrial use
6 and land use controls are required to prevent residential use of the site.
- 7 • As part of the industrial closure, it is recommended that the landfill be backfilled with
8 clean soil and graded to surface or elevated slightly above surface to prevent future
9 ponding of water.
- 10 • Continued sampling of the three groundwater monitoring wells at SWMU 28 is not
11 warranted (S-32-90, S-33-90, and S-34-90). However, annual water level
12 measurements should be collected at these three groundwater monitoring wells as part
13 of the TEAD-S base wide water-level monitoring event.

SECTION 1.0

INTRODUCTION

Tooele Army Depot-South Area (TEAD-S; formally known as Deseret Chemical Depot), in Tooele County, Utah, is investigating past waste disposal practices at solid waste management units (SWMUs) at the facility in accordance with the requirements of the TEAD-S Resource Conservation and Recovery Act (RCRA) Hazardous Waste Part B Permit, originally issued by the Utah Solid and Hazardous Waste Committee in 1989. This RCRA Facility Investigation (RFI) Addendum report details the recent investigation activities conducted at SWMU 28 and presents the results of the nature and extent evaluation. A risk assessment is also presented to satisfy the requirements of Utah Administrative Code (UAC) R315-101. This RFI Addendum was conducted in accordance with the *Final Work Plan - RCRA Facility Investigation Addendum for Solid Waste Management Units 19 and 28 at Deseret Chemical Depot* (Parsons, 2013a) and the *SWMU 28 Final Work Plan Addendum Memorandum: Plan for Additional Subsurface Soil Sampling* (Parsons, 2013b).

The addendum to the RFI is being conducted by Parsons under contract with United States Army Corps of Engineers (USACE) Sacramento District, pursuant to contract number W91238-06-D-0016, Delivery Order 0010. In addition to USACE, oversight of the RFI is being provided by TEAD-S and the US Army Environmental Command (USAEC). Regulatory coordination on this project is through the Utah Department of Environmental Quality (UDEQ) and the US Environmental Protection Agency (USEPA) Region VIII.

1.1 PROJECT PURPOSE AND SCOPE

SWMU 28 is a small, inactive (abandoned) landfill located near the Administrative Area of TEAD-S. The scope of the RFI included investigation of surface and subsurface soils and soil gas at the landfill. The primary objectives of the RFI Addendum were to characterize the nature and extent of contamination within the landfill and determine if contaminants have been released to the environment which pose a risk to human and ecological receptors.

1.2 REGULATORY FRAMEWORK

The TEAD-S RCRA Part B Permit has specific conditions requiring TEAD-S to perform corrective action investigations for all SWMUs and other corrective action sites identified in the permit. All environmental investigations, removals, and site closures conducted at TEAD-S are being performed under a corrective action program (CAP) and must be in accordance with State and Federal regulations and the TEAD-S RCRA Part B Permit. UDEQ's Division of Solid and Hazardous Waste (DSHW) is the regulatory authority for all RCRA environmental projects at TEAD-S. The authority for RCRA corrective action is derived from RCRA Section 3004(u) and is comprised of four phases:

- RCRA Facility Assessment (RFA) - Identifies releases and potential releases of hazardous wastes or constituents from the site.
- RFI - Verifies release(s) from the site and characterizes the nature and extent of contaminant migration.
- Corrective Measures Study (CMS) - Determines appropriate corrective measures for the site.
- Corrective Measures Implementation (CMI) – Provides the design, construction, operation and maintenance, and monitoring of the corrective measures.

Previous investigations at SWMU 28 include a RFA, Preliminary Assessment/Site Investigation (PA/SI), Phase I RFI field investigation and a 2012 test pit investigation. The Phase I RFI only included the installation and sampling of three groundwater monitoring wells. No soil or soil gas samples were collected during the Phase I RFI or during the test pitting operation conducted in 2012. As such, soil and soil gas have not been investigated at the site previously. Therefore, additional sampling was warranted at SWMU 28 and these investigations and results are discussed in this RFI Addendum report.

1.3 RFI ADDENDUM REPORT ORGANIZATION

This report contains the results of the RFI activities, including results of a nature and extent evaluation and human health and ecological risk assessment. The report is divided into eight sections and seven appendices, and contains the necessary elements as required by the RFI program.

- 1 **Section 1** **Introduction** – Presents the project overview including the regulatory
2 framework.
- 3 **Section 2** **Environmental Setting and Previous Investigations** – Provides a
4 description of the environmental settings of the TEAD-S installation and
5 SWMU 28. This section also describes the previous investigations and
6 activities conducted at SWMU 28.
- 7 **Section 3** **Nature and Extent Investigation Activities** – Describes the RFI approach
8 and activities conducted at SWMU 28.
- 9 **Section 4** **Data Quality Summary** – Summarizes the overall data quality and usability
10 of the samples collected during this investigation.
- 11 **Section 5** **Nature and Extent Investigation Results** – Provides the investigation
12 results.
- 13 **Section 6** **Human Health and Ecological Risk Assessment** – Provides an evaluation of
14 the risks associated with potential contamination at SWMU 28.
- 15 **Section 7** **Recommendations** – Summarizes human health and ecological risk screening
16 results along with a corrective action evaluation and recommendations.
- 17 **Section 8** **References** – A list of references used in the preparation of this report.

18 **Appendix A** Field Documentation

19 **Appendix B** Site Photographs

20 **Appendix C** Laboratory Data Packages and Data Validation Reports

21 **Appendix D** Analytical Results (excel searchable table)

22 **Appendix E** Site Attribution Analysis

23 **Appendix F** Investigation Derived Waste (IDW) Characterization and Disposal
24 Information

25 **Appendix G** Human Health and Ecological Risk Assessment Tables

SECTION 2.0

ENVIRONMENTAL SETTING AND PREVIOUS INVESTIGATIONS

1 This section presents the site description, history, and environmental setting of SWMU
2 28, including a summary of previous investigations.

2.1 FACILITY DESCRIPTION

3 TEAD-S is located in Tooele County, Utah, approximately 35 miles southwest of Salt
4 Lake City. The facility encompasses 19,364 acres in the northern portion of Rush Valley (Figure
5 2.1). Most of the facility is located on the east side of Rush Valley on gently southwestward-
6 sloping alluvial fans adjacent to the Oquirrh Mountains. The southern and western parts of the
7 facility are located on the relatively flat valley bottom. Figure 2.2 presents a detailed map of the
8 TEAD-S facility.

9 TEAD-S was constructed in 1942 and 1943 to serve as a storage and maintenance facility
10 for chemical munitions during World War II. In 1955, the depot was placed under the command
11 of Tooele Army Depot, renamed the Deseret Chemical Activity, and underwent a major
12 expansion. In 1962, the Deseret Chemical Activity became TEAD South. In October 1996, the
13 installation was officially transferred from the Industrial Operations Command to the Chemical
14 Biological Defense Command (CBDCOM), and the installation was renamed the Deseret
15 Chemical Depot (DCD). In July 2013, the installation was transferred to TEAD and renamed the
16 Tooele Army Depot-South Area, or TEAD-S.

17 The primary mission of TEAD-S was to store, renovate, and dispose of a wide array of
18 chemical munitions. Prior to the start of chemical demilitarization activities, TEAD-S stored
19 approximately 40-percent (by weight) of the total United States (U.S.) stockpile of lethal unitary
20 chemical agents. This stockpile consisted of two major types of chemical agents: blister agents
21 (including mustard gas) and nerve agents. From the 1940s through the late 1970s, chemical
22 weapons were demilitarized (explosive components deactivated) and disposed by burning and
23 burial. The Tooele Chemical Agent Disposal Facility (TOCDF), located near the southeast
24 corner of SWMU 2/11, was constructed from 1989 to 1993 for the destruction of chemical
25 munitions by incineration. Subsequent testing of the facility occurred from 1993 to 1996.
26 Destruction of chemical munitions at the TOCDF began in 1996 and continued until January

2012, at which time the last chemical munitions at TEAD-S were safely destroyed. The primary mission for TEAD-S of storing and demilitarizing chemical munitions has been completed. As such, facilities at the installation related to demilitarization are currently being closed.

2.2 SWMU DESCRIPTION AND SETTING

SWMU 28 is an inactive (abandoned) landfill encompassing approximately 0.3 acres, and is located approximately 1,000 feet (ft) southwest of the Administrative Area in the northeast region of TEAD-S (Figure 2.3; Inset 1). The landfill was used between 1963 and 1972 for the disposal of solid waste, paper, and building debris. Reportedly, no noxious or hazardous materials were disposed of at this site, and the landfill was filled to grade and revegetated in 1972, although details of the cover/cap are unknown (Ebasco, 1993). Based on test pitting conducted by TEAD-S in October 2012, the thickness of overburden at the landfill ranges from approximately one to two ft, and buried debris is present to a maximum depth of approximately 11 to 14 ft below ground surface (bgs). No landfill liner was observed during the test pit operations; as such, the landfill at SWMU 28 was likely an unlined disposal area.

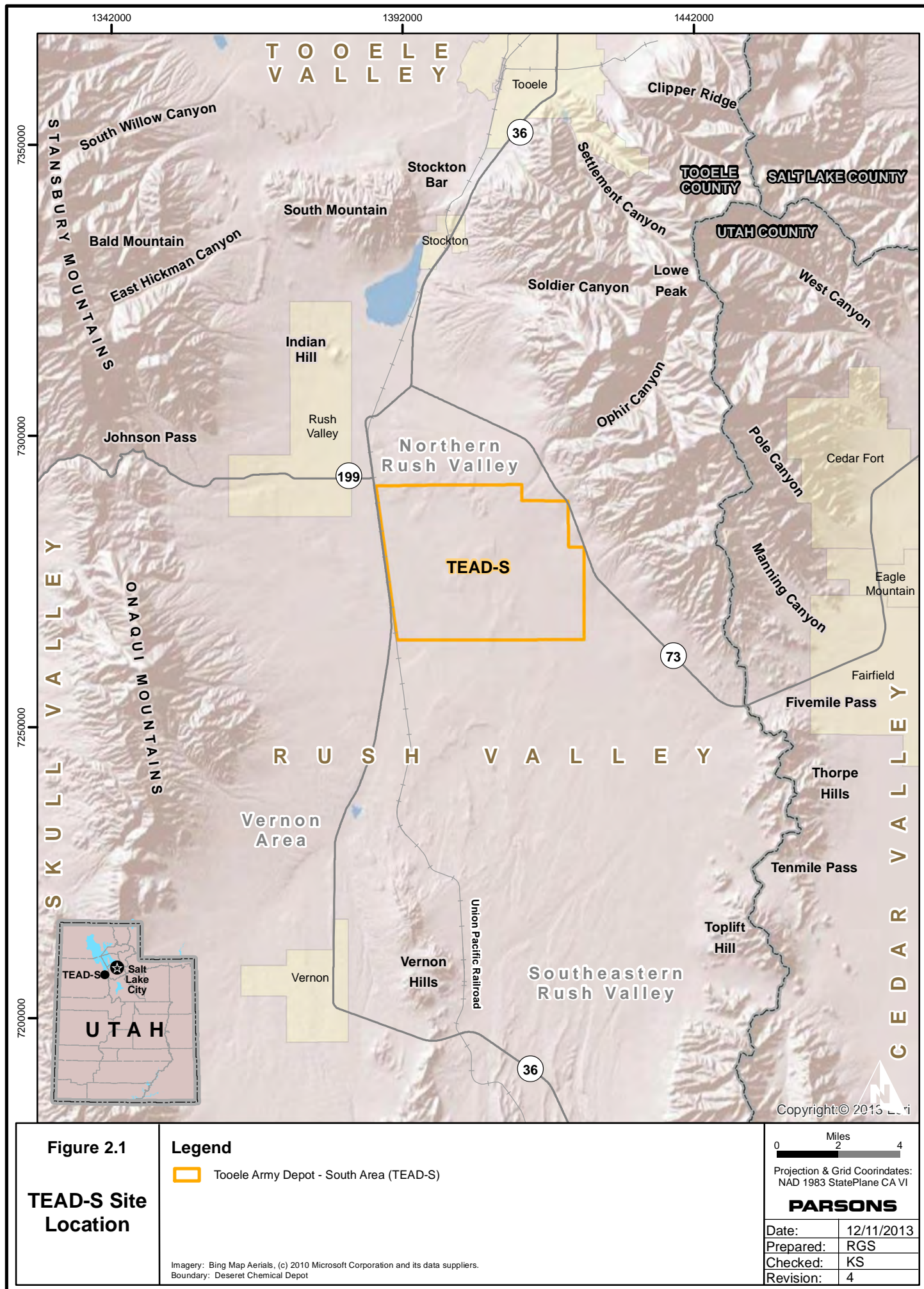


Inset 1 - The depressed trench feature shown in this photograph is SWMU 28.

A range fire in 2012 burned and removed all vegetation at the SWMU 28 site and exposed the landfill cover materials. The cover, comprised of gravel and cobble rich materials, is similar to the fill/cover material commonly seen at TEAD-S sites and is therefore believed to have originated from the installation's primary borrow pit.

2.2.1 Topography

The TEAD-S facility is located in northeastern Rush Valley. The surface topography of TEAD-S is generally flat with a gradual and gentle slope toward the west-southwest. SWMU 28 is located in the northeast portion of TEAD-S and lies at an elevation of approximately 5,320 feet (ft) above mean sea level (amsl).



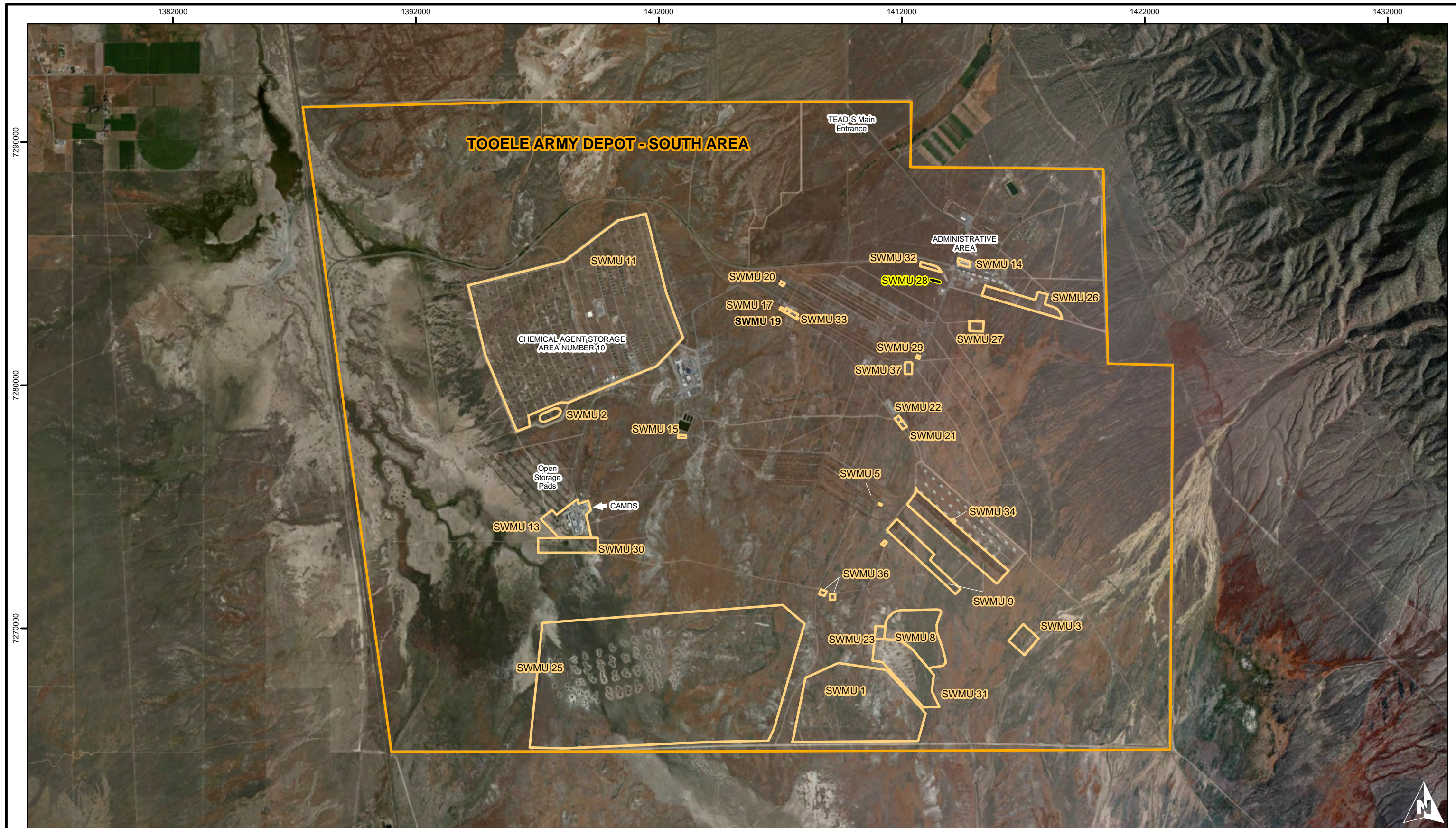


Figure 2.2

**SWMU 28
Location**

Legend

- SWMU 28
- SWMU Boundary
- Tooele Army Depot - South Area Boundary

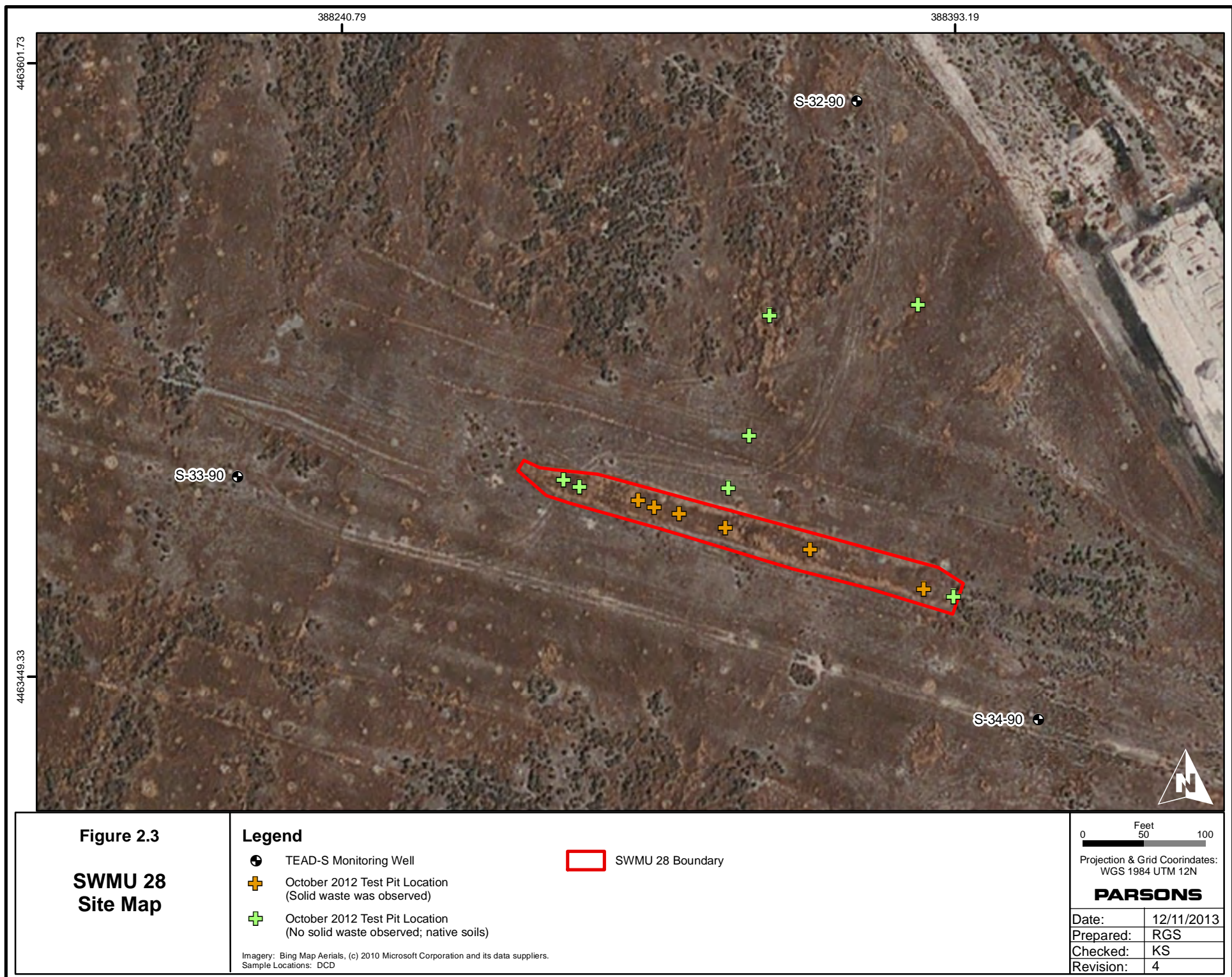
Imagery: Bing Map Aerials, (c) 2010 Microsoft Corporation and its data suppliers.
Boundary, SWMU: Deseret Chemical Depot

Miles
0 0.25 0.5

Projection & Grid Coordinates:
NAD 1983 StatePlane CA VI

PARSONS

Date:	12/11/2013
Prepared:	RGS
Checked:	KS
Revision:	6



2.2.2 Climate

The climate of Rush Valley is semi-arid with four well defined seasons. The area is noted for plentiful sunshine, low relative humidity, and light precipitation. Minimum temperatures between December and February can drop below 10°F. In summer, maximum daytime temperatures frequently exceed 90°F. Nighttime temperatures decrease considerably as colder air subsides from the surrounding mountain slopes into Rush Valley. Prevailing winds at TEAD-S are from the southeast, with occasional winds from the north-northwest. Average annual precipitation ranges from approximately 12 inches in the basin areas of Rush Valley to greater than 40 inches in the surrounding mountains. The majority of precipitation occurs as snowfall during the winter and early spring, and the least precipitation occurs during the hot summer months of July and August (Gardner and Kirby, 2011).

2.2.3 Vegetation

Vegetation at TEAD-S consists mainly of sagebrush, rabbitbrush, saltbush, and grasses (native and invasive varieties). The lack of precipitation during the summer months limits plant life to these drought resistant or drought tolerant species (AQS, 2013). Sparse vegetation has been observed at SWMU 28.

2.2.4 Geology and Soil

Rush Valley is part of the Great Basin section of the Basin and Range Physiographic Province. The mountains that surround Rush Valley are folded and faulted blocks of predominantly sedimentary rocks; igneous and metamorphic rocks are also present. The topographic relief is largely the result of extensional movement along normal fault systems, which generally trend northward (Kleinfelder, 1999). Rush Valley is comprised of a number of small horsts and grabens, common features associated with normal faulting in extensional tectonic regions. TEAD-S is situated on a structural feature known as the Mid-Valley Horst, which runs north-south near the center of TEAD-S. The TEAD-S facility is underlain by basin-fill sediments derived from alluvial and lacustrine processes. Sediment deposits across TEAD-S range from silty gravels/gravelly silts in the Ophir Creek alluvial fan deposits near the northeastern Depot boundary, to fine-grained silty clays with fine sand seams in lacustrine sediments that underlie the western and southwestern portions of the facility. Between these two

regions lies a transition zone of alluvial gravels and sands interbedded with clay-rich lacustrine deposits (Kleinfelder, 1999).

Based on geologic logs from three existing monitoring wells at the site (S-32-90, S-33-90, and S-34-90), SWMU 28 is underlain by coarse Quaternary alluvial gravels. The shallow subsurface at SWMU 28 is comprised of silt and silty gravel to approximately 25 ft below ground surface (bgs). This shallow interval is underlain primarily by silty and sandy gravel to approximately 220 ft bgs. The saturated zone is present below 220 ft and is composed of sandy and silty gravel with some gravelly clay (Ebasco, 1993).

2.2.5 Hydrogeology

Groundwater at TEAD-S is part of the regional flow system within Rush Valley. The groundwater underlying TEAD-S is recharged by intermittent streams and subsurface flow coming from the Oquirrh Mountains northeast of the facility (Parsons, 2013c). Groundwater flow at TEAD-S is influenced by the presence of a notable groundwater divide that crosses the facility from the northeast to the southwest. North of this divide, groundwater flow is generally to the west toward discharge points near the center of Rush Valley. South of the divide, groundwater is directed southeastward toward Cedar Valley (Gardner and Kirby, 2011). Shallow groundwater at TEAD-S generally occurs under unconfined conditions, although semi-confined and confined conditions exist in localized areas. Depth to groundwater beneath TEAD-S ranges from greater than 200 ft bgs at sites closer to the recharge areas in the northeast, to less than 10 ft bgs near discharge areas located along the TEAD-S western boundary (Parsons, 2013c).

Three groundwater monitoring wells were installed near SWMU 28 in 1990 (Figure 2.3). Well S-32-90 is located cross gradient and north of the SWMU 28 landfill, well S-33-90 is located upgradient and east of the landfill, and well S-34-90 is located downgradient and east of the landfill. From 1999 to 2012, the static water levels measured in these three wells ranged from 195 to 215 ft bgs. Based on observations of first water during drilling (approximately 210 to 230 ft bgs) and subsequent static water levels measured at more shallow depths, groundwater at SWMU 28 is under confined conditions. The groundwater flow direction at SWMU 28 is to the southeast over a gradient of approximately 0.002 ft/ft. Groundwater quality at SWMU 28 has been categorized as Class II – Drinking Water Quality Ground Water (Parsons, 2013c).

2.3 PREVIOUS INVESTIGATIONS

Previous investigations at SWMU 28 include a RFA, PA/SI, Phase I RFI field investigation, and a test pit investigation that was completed in 2012. Table 2.1 provides an overview of the previous investigations conducted at SWMU 28.

2.3.1 RCRA Facility Assessment (RFA)

A RFA was performed by NUS Corporation in 1987 to evaluate releases of hazardous wastes or hazardous constituents and to identify corrective actions, as necessary, under the Hazardous and Solid Waste Amendments of 1984 (Ebasco, 1993). The RFA provided information on SWMUs at TEAD-S, evaluated the potential for releases to the environment, and determined the need for further investigation. Based on the results of a file review and a site inspection, further investigation was recommended at SWMU 28 (Ebasco, 1993).

2.3.2 Preliminary Assessment/Site Investigation (PA/SI)

A PA/SI was conducted in 1988 by EA Engineering, Science, and Technology, Inc. to (1) identify TEAD-S sites that stored, processed, and/or disposed of hazardous waste; (2) determine which of these sites have a low potential for environmental contamination and/or pose no immediate apparent threat to public health and welfare; (3) determine which sites have a high potential for environmental contamination and/or pose a threat to public health and welfare; and (4) perform limited sampling of soil, groundwater, and/or surface water. The PA/SI found no indication of releases of toxic or hazardous material to the environment at SWMU 28 (Ebasco, 1993).

2.3.3 Phase I RFI

The Phase I RFI was conducted by Ebasco from 1990 to 1992 and consisted of the installation and sampling of three groundwater monitoring wells. No soil samples were collected during the Phase I RFI. One monitoring well was installed north of SWMU 28 (S-32-90) and two monitoring wells were installed south of SWMU 28 (S-33-90 and S-34-90; Figure 2.3). Groundwater samples collected during the Phase I RFI were analyzed for a full suite of groundwater analytes (volatile organic compounds [VOCs], semi-volatile organic compounds [SVOCs], metals, anions, explosive, and radionuclides). The following analytes were detected at low concentrations in the groundwater samples: cyclohexanone, methylene chloride, chloroform,

TABLE 2.1
SUMMARY OF PREVIOUS INVESTIGATIONS
 RCRA Facility Investigation Addendum Report for SWMU 28
 Tooele Army Depot - South Area

Investigation	Date	Purpose	Activities	Results
Preliminary Assessment/ Site Investigation	1988	Determine if contamination existed at the site.	Review of records and literature, site surveys, and onsite interviews with TEAD-S personnel.	No indication of releases of toxic or hazardous material to the environment at SWMU 28.
Phase I RFI Field Investigation	1990 and 1992	Assess the presence or absence of contamination and recommend further action if necessary.	Installation and sampling of three groundwater monitoring wells. Well S-32-90 is located cross gradient and north of the SWMU 28 landfill, well S-33-90 is located upgradient and east of the landfill, and well S-34-90 is located downgradient and east of the landfill. The wells are screened at depths between approximately 209 and 240 ft bgs.	Groundwater samples were analyzed for VOCs, SVOCs, explosives, anions, radionuclides, agent breakdown products, and metals. Cyclohexanone and explosives were identified as potential groundwater contaminants based on low level detections. However, these compounds were not detected during additional sampling efforts and the Phase I RFI report concluded no further groundwater sampling or delineation to address these earlier detections was warranted at the site. No soil samples were collected.
Landfill Test Pit	October 2012	Determine the cap thickness, determine the lateral and vertical extent of the landfill, and confirm the types of wastes buried in the landfill.	Thirteen test pits were excavated within the vicinity of SWMU 28.	Test pits showed the landfill covers approximately 0.3 acres and is limited to the a small depressed area of the settled backfilled trench near the southern boundary of SWMU-28. The cap thickness is approximately 2 feet and is mostly soil and cobbles, with sparse amounts of plastic debris interspersed. Landfill contents are solid wastes composed of municipal, construction, and household type debris, with a maximum thickness of approximately 6 feet. It is estimated that between 300 and 700 cubic yards of solid waste are present.

1 RDX and tertryl. As a result of these initial groundwater results, additional groundwater
2 samples were collected, and only methylene chloride was detected during the additional
3 sampling effort; however, this VOC detection was attributed to laboratory contamination
4 (Ebasco, 1993).

2.3.4 TEAD-S Groundwater Monitoring Program

5 The three monitoring wells near SWMU 28 were included in the TEAD-S groundwater
6 monitoring program that was initiated in 1995. The groundwater monitoring event was initially
7 conducted on a semiannual frequency through 1997 and then annually until 2010. Well S-33-90
8 was only sampled twice (1995 and 1996). For the remaining two wells (S-32-90 and S-34-90),
9 the sample frequency was inconsistent. Well S-33-90 was sampled a total of four times and well
10 S-34-90 was sampled a total of six times. In general, these two wells were sampled on different
11 years with different target analyte lists. Wells S-32-90 and S-34-90 were last sampled in 1999
12 and 2005, respectively (Parsons, 2013c). The historical results show that low concentrations of
13 SVOCs have been sporadically detected in each of the three groundwater wells. With the
14 exception for bis(2-ethylhexyl)phthalate, none of the detections exceeded their corresponding
15 maximum contaminant limit (MCL; USEPA, 2009). One isolated bis(2-ethylhexyl)phthalate
16 detection was reported above the MCL in well S-33-90 during sampling performed in 1995.
17 This analyte was not detected above the MCL in any SWMU 28 wells during subsequent
18 sampling events. No explosive detections were reported in the numerous groundwater samples
19 collected following the initial Phase I RFI sampling event (Parsons, 2013c).

2.3.5 Landfill Test Pit Investigation

20 In October 2012, TEAD-S excavated 13 test pits to determine the cap thickness, the
21 lateral and vertical extent of the landfill, and confirm the types of wastes buried in the landfill.
22 The test pits were excavated to the width of the excavator bucket and to a maximum depth of 11
23 ft bgs. A photograph of the test pit operation is shown on Inset 2. The test pits showed
24 conclusively that the SWMU 28 landfill is limited to a smaller depressed trench feature
25 approximately 130 ft northwest of monitoring well S-34-90, and encompassing approximately
26 0.3 acres (Figure 2.3). The remaining area outside the small depressed trench feature is native,
27 undisturbed soil.

1 The cover material thickness was shown to be approximately two feet. The debris zone
2 was found to be approximately six feet thick at its deepest point in the center of the landfill.

3 Buried debris in the trench was largely
4 municipal, construction, and household wastes
5 including foam padding, plastic sheeting, food
6 wrappers, metal straps, and empty containers,
7 although an isolated small area of oily rags or
8 material was excavated. The soils associated
9 with the oily rags yielded a 13 part per million
10 (ppm) reading on a photoionization detector
11 (PID); however, this was an isolated anomaly.
12 All other PID readings were between 0.0 to 0.3
13 ppm. The remainder of the debris observed
14 was solid waste with no indication of
15 hazardous materials or soil staining. No solid
16 waste was removed from the site. Also, no soil
17 samples were collected during the test pitting
18 excavations.



Inset 2 - October 2012 test pitting operations at SWMU 28. View is to the east.

SECTION 3.0

NATURE AND EXTENT INVESTIGATION ACTIVITIES

The objective of sampling at SWMU 28 was to determine if releases of contaminants had occurred within the landfill and if present, the nature and extent of contaminant releases. To achieve the objective, the following investigation activities were conducted:

- Thirty surface soil samples were collected;
- Fourteen soil gas samples were collected from seven collocated shallow and deep vapor monitoring points (VMPs); and
- Seven direct push soil borings were advanced to 25 ft bgs, with subsurface samples collected at five-foot intervals;

An initial representative sampling approach was used to investigate the landfill. The initial field investigation included surface soil sampling and installing and sampling a number of VMPs within the landfill. Subsurface soil sampling was not included in the initial sampling effort. Based on the preliminary results from this initial sampling, a follow-on investigation was performed to evaluate suspected release points within the landfill. This follow-on investigation included advancing seven soil borings. Details of the SWMU 28 field investigation are described below. Table 3.1 presents a summary of the samples collected for the investigation, and Figure 3.1 shows the locations of samples collected.

All field activities and laboratory analyses were conducted in accordance with the project Work Plan and related Quality Assurance Project Plan (QAPjP; Parsons, 2013a). Unexploded ordnance (UXO) avoidance methods and procedures were not required at SWMU 28 based on site history and previous investigations. Similarly, Chemical Warfare Materiel (CWM) was not suspected during SWMU 28 field activities.

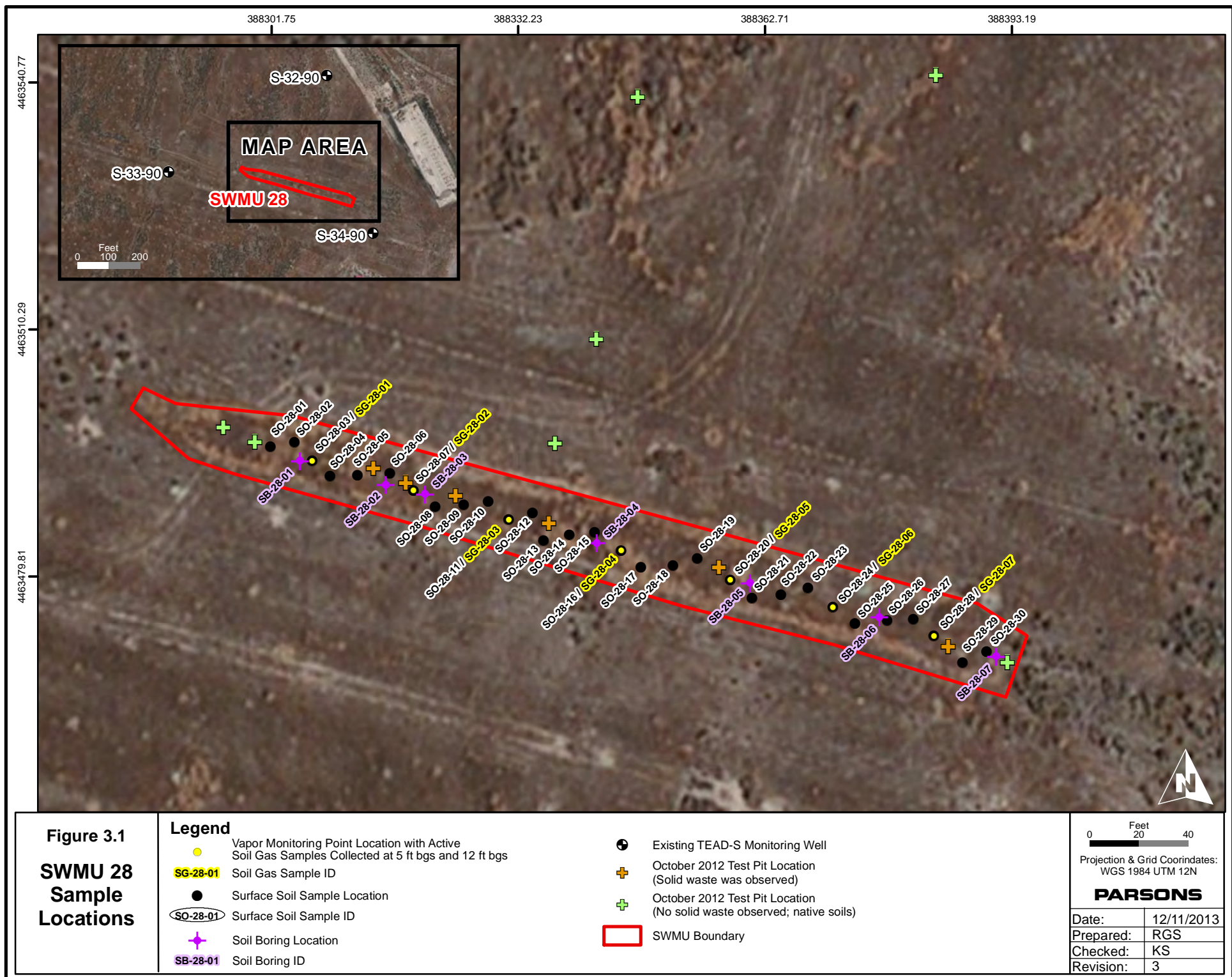
3.1 SURFACE SOIL SAMPLING

Thirty surface soil samples (DCD-SO-28-01 through DCD-SO-28-30) were collected from 0 - 0.5 ft bgs in March 2013. Surface soil samples were collected along the centerline of the landfill. This distribution of surface soil samples provided a representative sampling of the cover material placed over the landfill. Surface soil samples were not collected in areas

TABLE 3.1
INVESTIGATION OVERVIEW

RCRA Facility Investigation Addendum Report for SWMU 28
Tooele Army Depot - South Area

Field Activity	Location ID	# of Samples	#of Field Duplicates	Sample Depths (ft bgs)	Analyses Completed
Surface Soil Sampling	SO-28-01 thru SO-28-30	30	3	0-0.5	SVOCs, metals, explosives
Active Soil Gas Sampling	SG-28-01	2	0	5, 12	VOCs
	SG-28-02	2	0	5, 12	VOCs
	SG-28-03	2	0	5, 12	VOCs
	SG-28-04	2	1	5, 12	VOCs
	SG-28-05	2	0	5, 12	VOCs
	SG-28-06	2	0	5, 12	VOCs
	SG-28-07	2	1	5, 12	VOCs
Soil Borings	SB-28-01	5	0	5, 10, 15, 20, 25	VOCs, SVOCs, metals
	SB-28-02	5	1	5, 10, 15, 20, 25	VOCs, SVOCs, metals
	SB-28-03	5	0	5, 10, 15, 20, 25	VOCs, SVOCs, metals
	SB-28-04	5	1	5, 10, 15, 20, 25	VOCs, SVOCs, metals
	SB-28-05	5	0	5, 10, 15, 20, 25	VOCs, SVOCs, metals
	SB-28-06	5	1	5, 10, 15, 20, 25	VOCs, SVOCs, metals
	SB-28-07	5	1	5, 10, 15, 20, 25	VOCs, SVOCs, metals



1 disturbed during the 2012 test pit excavations. Sampling was performed in accordance with
2 standard operating procedure (SOP) 3.0 *Surface Soil Sampling* and the QAPjP (Parsons, 2013a).
3 At each sample location, soil was removed uniformly from within the sample area, using a
4 disposable trowel, and placed into a Zip-Lock® bag. The samples were thoroughly mixed
5 (homogenized) prior to filling the appropriate sample containers. All surface soil samples were
6 analyzed for SVOCs, metals, and explosives. The results from the surface soil sampling event
7 are discussed in Section 5.0 and analytical data is presented in tabular form in Appendix D.

3.2 ACTIVE SOIL GAS SAMPLING

8 Fourteen active soil gas samples were collected from seven collocated shallow and deep
9 VMPs at SWMU 28 in March 2013. Based on test pitting conducted by TEAD-S in October
10 2012, the thickness of overburden at the landfill ranges from approximately one to two ft, and
11 buried debris is present to a maximum depth of approximately 11 ft bgs. Therefore, collocated
12 soil gas samples were collected at depths of 5 ft bgs within the zone of buried waste and at
13 approximately 12 ft bgs, from just below the buried waste. The seven collocated VMPs (SG-28-
14 01 through SG-28-07) were installed along the centerline of the landfill. Locations of the VMPs
15 are shown on Figure 3.1.

16 Each VMP was installed with the standardized process detailed in SOP 2.0 *Near-Surface*
17 *Soil Vapor Sampling* (Parsons, 2013a). For each VMP, a direct push drill rig was used to make a
18 2-inch diameter hole 2 inches deep into the subsurface. Afterwards, the drill bit was changed
19 and a 1 1/8-inch diameter hole was extended through the soil column. Each hole was drilled to a
20 total depth of either 5 or 12 ft bgs for collocated shallow and deep samples. A 6-inch-long
21 stainless steel Geoprobe® soil gas sampling implant connected to 1/4-inch polytetrafluoroethylene
22 (PTFE) tubing was used for the VMP. The annulus around the implant was backfilled with sand
23 pack to 3-inches above the probe screen. A clay seal composed of hydrated Cetco Puregold
24 medium bentonite chips was placed on top of the sand and filled upwards to the ground surface.
25 Each VMP was allowed to equilibrate for at least 24 hours prior to leak testing and sampling.

26 Prior to sampling, a static leak test of the sampling train was conducted at each port to
27 ensure no ambient air intruded into the soil gas stream during sample collection. Following the
28 static leak test, each VMP port was purged a minimum of five volumes to evacuate ambient air;
29 during which time PID readings were also collected at regular intervals to assess stabilization of

1 the vapor. Concurrently throughout VMP purging, a tracer gas test was performed to confirm no
2 leaks were occurring through the grouted borehole into the VMP train. Helium gas has
3 historically been used as the tracer gas used in leak detection when sampling VMPs, however,
4 due to a global shortage, helium became unavailable in 2012. In place of helium, a 5-percent
5 hydrogen, 95-percent nitrogen (H5N95) gas mixture was used as the tracer gas on this project.
6 The purging and sampling procedures, including descriptions of the static and leak tests, are
7 detailed in SOP 2.0 *Near-Surface Soil Vapor Sampling* (Parsons, 2013a).

8 Soil gas samples were collected in 1-liter Summa® canisters. The canisters were
9 certified clean and provided by Parsons subcontractor laboratory. Flow controllers calibrated to
10 200 milliliters (ml) per minute were used to control the rate of air flow into each Summa®
11 canister during sample collection. Unique flow controllers were assigned and used with each
12 Summa® canister to avoid potential cross contamination between samples.

13 For each sample, after the purging was completed, the air pump ball-valve was closed,
14 and the valve of the Summa® canister, which is under a vacuum, was opened to draw subsurface
15 air into the canister. Once the vacuum inside the Summa® canister had approximately 5 inches
16 mercury (Hg) of residual vacuum, the valve on the Summa® canister was closed. Residual
17 vacuum was required in each canister to ensure sample integrity during shipping. All
18 measurements and field conditions were recorded in the field logs (Appendix A). The vapor
19 samples were shipped to the subcontractor commercial laboratory for analysis of VOCs by
20 USEPA method TO-15. The active soil gas results are discussed in Section 5.0 and analytical
21 data is presented in tabular form in Appendix D.

3.3 DIRECT PUSH DRILLING AND SUBSURFACE SOIL SAMPLING

22 Active soil gas results from the initial sampling effort in March 2013 found maximum
23 soil gas detections were largely in the deeper samples (12 ft bgs interval). Based on the deeper
24 nature of the soil gas detections, further evaluation of subsurface soils was necessary to assess
25 the nature and extent of contamination at SWMU 28. The follow-on sampling conducted at the
26 landfill included advancing seven soil borings to 25 ft bgs; these activities were completed in
27 October 2013. Samples from the borings were collected from 5, 10, 15, 20 and 25 feet bgs. All
28 soil samples collected were analyzed for VOCs, SVOCs, and metals. Locations of the boreholes
29 are provided on Figure 3.1 and are described below:

- Three soil borings (SB-28-01 through SB-28-03) were advanced in the western portion of the site near soil gas samples SG-28-01 and SG-28-02. Maximum detected VOC concentrations were predominantly detected from these two sample locations.
- The remaining four soil borings (SB-28-04 through SB-28-07) were distributed evenly across the eastern portion of the landfill. This distribution provided a representative sampling of the soils in and under the landfill.

The proposed boring location of SB-28-07 was placed in an area that was disturbed during the test pit excavations conducted by TEAD-S in October 2012. Therefore, the onsite geologist moved the placement of boring SB-28-07 approximately 5 ft bgs west toward vapor monitoring point SG-28-07, an area not previously disturbed. Soil borings were completed using direct push drilling methods and sampling was performed in accordance with SOP 1.0 *Direct Push Soil Sampling* and the QAPjP (Parsons, 2013a). The direct push rig collected continuous soil core in lengths of approximately four feet using a Macro-core open-tube sampler. A Parsons earth sciences professional logged each boring and collected soil core samples at the specified depth intervals (i.e., 5, 10, 15, 20 and 25 ft bgs). Appendix A presents the detailed lithologic logs and field notes recorded during soil boring activities. Photos of the direct push drilling operations are provided in Appendix B. The locations of all soil borings were recorded using a handheld global positioning system (GPS) unit.

The soil cores from each boring were field screened for VOCs with a Mini-Rae PID equipped with a 10.6 electron volt (eV) lamp for detection of TCE, PCE, and other fuel-related contaminants. The purpose of the PID field screening was to identify specific subsurface soil intervals with elevated PID detections for sampling. The PID instrument was calibrated daily using a 10 ppm isobutylene span gas standard. The observed PID readings were noted in the field logbook and on the geologic boring logs (Appendix A).

Following PID field screening, soil samples were collected directly from the soil core from 5, 10, 15, 20 and 25 ft bgs. Samples were collected in appropriate sample containers supplied by the subcontractor commercial laboratory. Soil samples collected for VOC analysis were obtained using En Core™ samplers. To minimize volatilization of VOCs in the sample, VOC samples were collected first, following PID screening, and before collection of samples for other analytical suites. All soil samples were containerized and shipped to the subcontractor laboratory and analyzed for VOCs, SVOCs, and metals. Completed borings were backfilled to

1 the surface with hydrated Cetco Puregold medium bentonite chips. The results from the soil
2 boring sampling event are discussed in Section 5.0 and analytical data is presented in tabular
3 form in Appendix D.

3.4 INVESTIGATION DERIVED WASTE MANAGEMENT

4 The investigation derived waste (IDW) generated during field activities was managed and
5 disposed in accordance with the Waste Management Plan (Section 2.7 of the project Work Plan
6 [Parsons, 2013a]). The IDW characterization and disposal information, including the waste
7 tracking log and disposal documentation, is included in Appendix E.

3.4.1 Equipment Decontamination

8 All reusable field equipment, including sampling tools, drill rod, core samplers, and all
9 other equipment that came into contact with environmental media were cleaned and
10 decontaminated in accordance with SOP 9.0 *Field Equipment Decontamination* (Parsons,
11 2013a). Equipment decontamination was done by hand, utilizing five-gallon wash buckets. All
12 wash and rinse water generated as a result of equipment decontamination was containerized,
13 profiled, and disposed of in accordance with the Waste Management Plan (Parsons, 2013a).

3.4.2 Decontamination/Rinse Water

14 Equipment decontamination water related to field work at SWMU 28 was containerized
15 and stored in a United States Department of Transportation (USDOT) approved, closed head, 55-
16 gallon drum. Two decontamination water IDW drums were filled and stored on wood pallets in
17 the designated IDW drum staging area (IDW drums PGS1307102 and PGS1328802). Drum
18 PGS1307102 also included decontamination water generated from concurrent field activities
19 conducted at SWMU 19 and SWMU 27. The drums were labeled in accordance with the Waste
20 Management Plan (Parsons, 2013a). Weekly inspections were conducted to evaluate the
21 condition of these drums, and these inspection logs are presented in Appendix E.

22 A composite sample was collected from each of the decontamination water IDW drums
23 and analyzed for total VOCs and SVOCs (sample IDs: DCD-IDW-WA-19/27-01 and DCD-
24 IDW-WA-28-01). The IDW analytical results are presented in Appendix D and discussed in
25 Section 5.0.

3.4.3 Soil Cuttings

1 The direct push drill cores were containerized and stored in USDOT approved, open end,
2 55-gallon drums. A total of two soil IDW drums were filled and stored on wood pallets in the
3 designated IDW drum staging area (IDW drums PGS1307101 and PGS1328801). Drum
4 PGS1307101 also included drill cuttings generated from concurrent field activities conducted at
5 SWMU 19. All of the drums were labeled in accordance with the Waste Management Plan
6 (Parsons, 2013a). Weekly inspections were conducted to evaluate the condition of the drums
7 (Appendix E).

8 Following completion of the soil borings, the soil IDW drums were sampled and
9 analyzed for toxicity characteristic leaching procedure (TCLP) VOCs and TCLP RCRA metals
10 (sample IDs: DCD-IDW-SO-19-01 and DCD-IDW-SO-28-01). The analytical results are
11 presented in Appendix D and discussed in Section 5.0.

SECTION 4.0

DATA QUALITY SUMMARY

1 This laboratory data quality summary describes the findings of the review of data from
2 the 2013 sampling event at SWMU 28. This section serves to summarize the issues found and
3 convey overall data quality for this sampling event. Data review for this project was performed
4 in accordance of the project QAPjP (Parsons, 2013a). Specific details regarding each sample
5 delivery group (SDG) can be found in the associated Data Validation Report (DVR) prepared for
6 each SDG, included in Appendix C of this report. Sampling procedures and overall quality
7 control (QC) and quality assurance protocols are presented in the project QAPjP (Parsons,
8 2013a).

9 An initial field investigation was conducted in March 2013 and included surface soil
10 sampling and installing and sampling a number of VMPs within the landfill. A follow-on
11 investigation was performed in October 2013 and included advancing seven soil borings with
12 subsurface samples collected at five-foot intervals. Thirty surface soil samples, three soil field
13 duplicate samples, one equipment blank, and one source blank were collected on March 13,
14 2013. The samples were analyzed for SVOCs, explosives, metals and mercury. Thirty-five
15 subsurface soil samples, four soil field duplicate samples, one equipment blank, and two trip
16 blanks were collected on October 15 and 16, 2013. The samples were analyzed for VOCs,
17 SVOCs, metals and mercury. All soil analyses were performed by Test America, Inc., in Saint
18 Louis, Missouri. The laboratory holds current U.S. Department of Defense (DoD) Environmental
19 Laboratory Accreditation Program (ELAP) accreditation for the listed analyses, and is National
20 Environmental Laboratory Accreditation Program (NELAP) certified by the State of Utah
21 Department of Health for the analyses. All soil sample results were reported on a dry weight
22 basis as required by the TEAD-S QAPjP. Fourteen active soil gas samples and two field
23 duplicate samples were collected from SWMU 28 on March 26 and 27, 2013. The active soil
24 gas samples were analyzed for VOCs using Compendium Method TO-15 by Eurofins Air Toxics
25 in Folsom, California.

26 Data review for this project was performed following the validation requirements detailed
27 in the performance work statement (PWS) for this contract. Specifically, the data review
28 incorporated the following stages (i.e., levels) of data review and validation, as follows:

Stage 1 Validation (IDW data)

- Checks include completeness of the data package which may include hardcopy, electronic or both to ensure that the data present are consistent within the hardcopy summary tables and instrument outputs as well as between the hardcopy and electronic deliverables, if present.

Stage 2a Validation is based on Sample-Related Quality Control results (100-percent)

- Checks include those listed in Stage 1, plus review of method blanks, laboratory control samples, surrogates, matrix spikes, and post digestion spikes.

Stage 2b Validation is based on Sample-Related Quality Control and Instrument-Related Quality Control results (100-percent)

- Checks include those listed in Stage 1 and Stage 2a, plus review of initial calibrations, continuing calibration verifications, tunes and instrument performance checks.

Stage 3 Validation (minimum of 10-percent)

- Checks include those listed in Stage 1, Stage 2a, and Stage 2b, plus re-calculating laboratory reported sample results using instrument output results, dilution factors, calibration factors, percent moisture (for solid samples).

Stage 4 Validation (minimum of 10-percent)

- Checks include those listed in Stage 1, Stage 2a, Stage 2b, and Stage 3, plus a review of instrument outputs like chromatograms, mass spectra, and Inductively Coupled Plasma (ICP) spectra.

A Parsons chemist manually performed a data review on the analytical results at stages ranging from Stage 2b to Stage 4 as described in the PWS for this contract. A minimum of 10-percent of the analytical data was reviewed at a Stage 3 or Stage 4 level, as required by the PWS. Appendix D, Table D.5 summarizes the sample identification numbers, sample collection, preparation and analysis dates, preparation and analytical methods, and data review levels. The review was performed in accordance with the guidelines and control criteria specified in the following documents:

- SWMU 19/28 QAPjP (Parsons, 2013a)
- DoD Quality Systems Manual (QSM) for Environmental Laboratories (Version 4.2) (2010)
- Engineering Manual (EM) 200-1-10, Guidance for Evaluating Performance-Based Chemical Data (USACE, 2005)

- Test Methods for Evaluating Solid Wastes, SW-846 Physical/Chemical Methods (USEPA, 2008 and updates)

Stage 4 data validation was performed on the soil and QC samples included in laboratory submission 160-4130. Stage 4 validation was also performed on all active soil gas data. Stage 2b data validation was performed on all other data associated with the 2013 sampling at SWMU 28 (160-1775 and 160-4138). It should be noted that a Level III review corresponds to a Stage 2b validation and a Level IV review corresponds to a Stage 4 validation. Therefore, the data review requirements listed in the project QAPjP (Parsons, 2013a) were met.

The laboratory data reports provided in Appendix C contain laboratory-applied data qualifiers. Qualifiers added, removed, or changed as a result of the data validation process are entered into the project database and are reflected in the data tables presented in Appendix D of this report. All data qualifier changes are documented in the associated DVRs (provided in Appendix C) for each SDG and are discussed in the sections below.

Data were reviewed in terms of precision, accuracy, representativeness, comparability, and completeness:

- Precision is evaluated using the relative percent difference (RPD) obtained from the laboratory control sample (LCS)/ LCS duplicate (LCSD) concentrations and matrix spike (MS)/matrix spike duplicate (MSD) concentrations. Precision is further evaluated by comparing the analyte results of replicate sample analyses, including field duplicates and laboratory (or analytical) duplicates. The RPD is calculated for duplicate results if both the parent and duplicate concentration exceeds the limit of quantitation (LOQ). When analyte RPDs exceed the acceptance criteria, the data are flagged accordingly. If excessive RPD exceedances are identified, the sampling and analytical techniques may be reviewed to determine if protocols are being followed.
- Accuracy is demonstrated by recovery of target analytes from fortified blank and sample matrices, which are LCS/LCSD and MS/MSD, respectively. For organic methods, accuracy is also demonstrated through recovery of surrogates from each field and QC sample. The recovery of target analytes from fortified samples is compared to the acceptance criteria defined in the project QAPjP. When acceptance criteria are not met, the data are qualified accordingly.
- Representativeness of the sample data is ensured by adherence to standard sampling techniques and protocols (including preparation and analytical holding times and sample storage temperatures), the evaluation of laboratory blanks, and through the

collection of field blanks (including trip blanks, source blanks, and equipment blanks).

- Comparability of sample results is ensured through the use of approved sampling, preparation, and analysis methods using standardized equipment, reporting conventions and units.
- Completeness is expressed as a ratio of the number of usable data to all analytical data.

The following sections provide a discussion of the data review findings. All analytical results are included in Appendix D. The discussion in this section focuses on the significant review findings. As previously noted, a detailed discussion of all findings is included in the DVR associated with each data package, located in Appendix C.

4.1 PRECISION

Precision was evaluated using the relative percent difference obtained from the field duplicate samples, analytical duplicate samples (for soil gas only), the MS/MSD samples, and the LCS/LCSD samples. Precision was further evaluated for metals only using the serial dilution test percent difference. Data qualifiers applied to the data due to precision issues are described in the following sections. Both field and analytical precision were generally acceptable for this data set. No systematic bias was found. However, in general, the samples demonstrated non-homogeneity with respect to metals as detailed below.

4.1.1 Field Duplicate Samples

Field duplicates were collected at the required frequency, per the project QAPjP (Parsons, 2013a). Seven soil field duplicates were collected for 65 normal environmental soil samples. No target VOCs or explosives were detected at or above the LOQ in any of the parent or field duplicate samples. No target SVOCs were detected at or above the LOQ in any of the parent or field duplicate samples with one exception. Bis(2-ethylhexyl)phthalate was detected in parent sample DCD-SB-28-06-05 and the associated field duplicate. The RPD for this analyte exceeded the maximum RPD of 40-percent as follows:

Sample ID	Analyte	Parent (mg/Kg)	FD (mg/Kg)	RPD
DCD-SB-28-06-05	Bis(2-ethylhexyl) phthalate	0.37	2.2	142

The parent and field duplicate sample results for bis(2-ethylhexyl)phthalate were qualified “J” as estimated due to the variability demonstrated by the field duplicate pair. Bis(2-ethylhexyl)phthalate was only detected in two other samples from this site and both detections were below the LOQ. Mercury met RPD criteria in all seven field duplicate pair.

Metals demonstrated good precision in several field duplicates and significant heterogeneity in others. All metals detected at or above the LOQ in both the parent and field duplicate met RPD criteria for DCD-SO-28-10 and DCD-SB-28-04-25. All metals met RPD criteria for parent sample DCD-SO-28-20 and the associated field duplicate with the exception of lead, as follows:

Sample ID	Analyte	Parent (mg/Kg)	FD (mg/Kg)	RPD	Criteria
DCD-SO-28-20	Lead	15	30	67	RPD \leq 40

Lead was qualified “J” as estimated in the parent and field duplicate samples due to the variability demonstrated.

All metals met RPD criteria for parent sample DCD-SO-28-30 and the associated field duplicate with the exception of iron, as follows:

Sample ID	Analyte	Parent (mg/Kg)	FD (mg/Kg)	RPD	Criteria
DCD-SO-28-30	Iron	10000	16000	46	RPD \leq 40

Iron was qualified “J” as estimated in the parent and field duplicate samples due to the variability demonstrated.

All metals detected at or above the LOQ in parent sample DCD-SB-28-04-15 and the associated field duplicate failed to meet criteria, as follows:

Sample ID	Analyte	Parent (mg/Kg)	FD (mg/Kg)	RPD	Criteria
DCD-SO-28-04-15	Aluminum	17000	3200	137	RPD \leq 40
	Arsenic	12	25	70	
	Barium	200	35	140	
	Cadmium	1.2	0.75	46	
	Calcium	100000	2100000	71	
	Chromium	27	10	92	
	Cobalt	7.8	2.6	100	
	Copper	23	7.8	99	

Sample ID	Analyte	Parent (mg/Kg)	FD (mg/Kg)	RPD	Criteria
DCD-SO-28-04-15 (Continued)	Iron	22000	6600	108	
	Lead	40	19	71	
	Magnesium	23000	27000	16	
	Manganese	660	350	61	
	Nickel	23	12	63	
	Potassium	6600	790	157	
	Sodium	950	350	92	
	Vanadium	29	11	90	
	Zinc	980	56	78	

The high degree of variability for this field duplicate pair was highly suspicious. At Parsons' request, the laboratory reviewed the digestion logs, the sample and digestate labels, and the run logs to determine if any transcription errors were made. The laboratory indicated that no issues were found and attributed the variability to the sample matrix, which consisted of a mixture of rocks and soil. However, it seems unlikely that all metals would demonstrate the variability found. All non-compliant metals were flagged "J" in the parent and field duplicate samples.

All metals detected at or above the LOQ in parent sample DCD-SB-28-06-05 and the associated field duplicate met RPD criteria, except for the following:

Sample ID	Analyte	Parent (mg/Kg)	FD (mg/Kg)	RPD	Criteria
DCD-SO-28-06-05	Calcium	110000	190000	53	RPD \leq 40
	Iron	28000	51000	58	
	Lead	81	150	60	
	Magnesium	9200	17000	60	
	Manganese	360	560	44	
	Potassium	1500	2300	42	
	Vanadium	12	22	59	
	Zinc	110	230	71	

All non-complaint metals were qualified "J" as estimated in the parent and field duplicate samples due to the variability demonstrated. The laboratory indicated that the samples were a heterogeneous mix of soil and rock, resulting in the high RPDs.

All metals detected at or above the LOQ in parent sample DCD-SB-28-07-20 and the associated field duplicate met RPD criteria, except for the following:

Sample ID	Analyte	Parent (mg/Kg)	FD (mg/Kg)	RPD	Criteria
DCD-SO-28-04-15	Barium Magnesium	30 28000	170 15000	140 60	RPD \leq 40

Barium and magnesium were flagged “J” as estimated in the parent and field duplicate pair due to the variability demonstrated.

The field duplicate results for soil gas demonstrated a high degree of variability for acetone and m/p-xylene, as noted in the following table. All soil gas concentrations are listed in ppbv.

Sample ID	Analyte	Parent	FD	RPD	Criteria
DCD-SG-28-04-12	Acetone	26	88	109	RPD \leq 35
DCD-SG-28-07-12	Acetone m/p-Xylene	33 2.1	190 4.6	190 75	RPD \leq 35

Due to the high degree of variability demonstrated for acetone, all soil gas results for acetone were qualified “J” as estimated. The m/p-xylene results in sample DCD-SG-28-07-12 and the associated field duplicate were qualified “J” as estimated. The chromatograms for these samples were inspected and no unusual matrix interference was found. Therefore, no additional corrective action was necessary.

4.1.2 Analytical Duplicate Samples

One analytical duplicate was performed for each TO-15 analytical batch. The laboratory performed an analytical duplicate on soil gas sample DCD-SG-28-01-05. All VOCs detected met RPD criteria in the laboratory duplicate.

4.1.3 Matrix Spike / Matrix Spike Duplicate Samples

Matrix spike / matrix spike duplicate samples were collected at the required frequency. Four MS/MSD pair were collected for 65 normal environmental soil samples. Precision was evaluated using the RPD obtained from the MS/MSD concentrations. All MS/MSD RPDs were within acceptance criteria for explosives and mercury.

All MS/MSD RPDs were within acceptance criteria for VOCs, with one exception. For the MS/MSD analyzed on parent sample DCD-SB-28-06-05, 16 of the 65 analytes spiked failed to meet RPD criteria. The laboratory noted that the aliquot size used for the MS and MSD differed by more than 10-percent. Since the MS/MSD RPD is calculated using the concentrations found, the non-compliant RPDs were attributed to the difference in aliquot size between the MS and MSD. In addition, all analytes were non-detect in the parent sample, so data quality was not affected and no data qualifiers were applied.

Due to laboratory error, the MS/MSD pair analyzed on samples DCD-SO-28-20 and DCD-SO-28-30 were not spiked for the SVOC analytes benzyl alcohol or n-nitrosodimethylamine. Therefore, precision for these two analytes could not be evaluated using the MS/MSD concentrations. Precision for these compounds was evaluated using the field duplicate analyte results and met criteria as discussed previously. Therefore, qualification of the data was not deemed necessary. All MS/MSD RPDs were within acceptance criteria for SVOCs, except for the following:

Sample ID	Analyte	MS/MSD RPD	Criteria
DCD-SO-28-20	Hexachlorocyclopentadiene	31	RPD \leq 30
DCD-SB-28-02-25	2,4-Dinitrophneol	51	
	n-Nitrosodimethylamine	33	

All three non-compliant analytes were non-detect in the associated parent samples. Therefore, data quality was not affected by the MS/MSD variability and no data qualifiers were applied.

All MS/MSD RPDs were within acceptance criteria for metals, except for the following:

Sample ID	Analyte	MS/MSD RPD	Criteria
DCD-SO-28-30	Magnesium	38	RPD \leq 20
DCD-SB-28-02-25	Calcium	21	
	Magnesium	32	
DCD-SB-28-04-20	Calcium	27	
DCD-SB-28-06-05	Calcium	31	
	Lead	24	
	Zinc	95	

The parent sample concentrations for calcium and magnesium were significantly greater than (more than 8 times) the concentration spiked, resulting in the anomalous RPDs. Thus, no

data qualifiers were applied for these metals. Lead and zinc were qualified “J” as estimated in parent sample DCD-SB-28-06-05 due to the RPD failures and MS/MSD accuracy failures discussed in the following section.

Matrix spike / matrix spike duplicate samples are not applicable to soil gas.

4.1.4 LCS/LCSD Samples

For soil and the associated water QC samples, the laboratory analyzed an LCS/LCSD pair in every batch for VOCs, and prepared an LCS/LCSD pair for all water preparation batches for SVOCs. For all batches that contained an LCS/LCSD pair, all LCS/LCSD RPDs were within acceptance criteria.

For soil gas, the laboratory analyzed an LCS/LCSD pair in each batch. All LCS/LCSD RPDs were within acceptance criteria for soil gas.

4.1.5 Serial Dilution Test

The serial dilution test was used to evaluate precision for metals. The serial dilution test is applicable for all metals detected in the parent sample at a concentration of 50 times the LOQ or greater. The laboratory analyzed serial dilutions at the appropriate frequency. All metals met criteria in the serial dilution tests, except for the following:

Sample ID	Analyte	%D (percent difference)	Criteria
DCD-SO-28-20	Aluminum	11	%D ≤ 10
	Iron	12	
	Magnesium	16	
	Manganese	11	

No data qualifiers were applied as a result of the non-compliant metals, in accordance with the TEAD-S QAPP.

4.2 ACCURACY

Accuracy was evaluated using the surrogate spike, MS/MSD, LCS/LCSD, initial calibration verification (ICV), and continuing calibration (CCV) recoveries. Accuracy was generally acceptable for this data set, although systematic bias was found for three SVOC

analytes, and laboratory error affected the evaluation of two additional SVOC analytes. These issues are discussed below. Qualifiers applied as a result of accuracy issues are detailed below.

4.2.1 Surrogate Spikes

Surrogate recoveries were generally acceptable for this data set. All surrogate recoveries met criteria for explosives.

The VOC surrogates 4-bromofluorobenzene (4-BFB) and toluene-d8 were recovered slightly high in the samples collected during the follow-on sampling event (October 2013), as follows:

Sample ID	Surrogate	%R	Criteria
DCD-SB-28-01-05	4-Bromofluorobenzene	131	85-120%
DCD-SB-28-01-10	4-Bromofluorobenzene	132	85-120%
DCD-SB-28-01-15	4-Bromofluorobenzene	134	85-120%
	Toluene-d8	116	85-115%
DCD-SB-28-01-20	4-Bromofluorobenzene	121	85-120%
DCD-SB-28-02-10	4-Bromofluorobenzene	127	85-120%
DCD-SB-28-02-20	4-Bromofluorobenzene	126	85-120%
DCD-SB-28-04-15FD	4-Bromofluorobenzene	121	85-120%
DCD-SB-28-04-25	4-Bromofluorobenzene	128	85-120%
DCD-SB-28-05-10	4-Bromofluorobenzene	129	85-120%
	Toluene-d8	118	85-115%
DCD-SB-28-05-15	4-Bromofluorobenzene	121	85-120%
DCD-SB-28-06-05	4-Bromofluorobenzene	142	85-120%
	Toluene-d8	120	85-115%
DCD-SB-28-06-05FD	4-Bromofluorobenzene	125	85-120%
DCD-SB-28-06-10	4-Bromofluorobenzene	128	85-120%
	Toluene-d8	123	85-115%
DCD-SB-28-06-15	4-Bromofluorobenzene	124	85-120%
	Toluene-d8	118	85-115%
DCD-SB-28-06-20	Toluene-d8	117	85-115%
DCD-SB-28-06-25	4-Bromofluorobenzene	123	85-120%
DCD-SB-28-07-05	Toluene-d8	117	85-115%
DCD-SB-28-07-10	4-Bromofluorobenzene	123	85-120%
	Toluene-d8	118	85-115%
DCD-SB-28-07-15	4-Bromofluorobenzene	123	85-120%

All surrogates were recovered high and all analytes were either non-detect or detected below the LOQ and thus already qualified “J” in these samples. Therefore, data quality was not affected and no corrective action was necessary. The high surrogate recoveries appear to be due to a high laboratory spike. The chromatograms for these samples were clean and did not show any matrix issues or interference. All samples with high surrogate recoveries were analyzed on the same instrument over the period of three days. It appears likely that the standard used on this instrument was biased high or that the instrument was spiking slightly high. The laboratory was notified of the issue. However, since data quality was not affected, no additional corrective action was deemed necessary.

Two samples had non-compliant surrogates for SVOC due to matrix issues, as follows:

Sample ID	Surrogate	%R	Criteria
DCD-SB-28-06-10	2-Fluorobiphenyl	15	35-105%
	2,4,6-Tribromophenol	12	35-125%
DCD-SB-28-02-15	2-Fluorobiphenyl	115	45-105%
	2-Fluorophenol	120	35-105%
	Nitrobenzene-d5	114	35-100%
	Phenol-d5	124	40-100%

The laboratory indicated that the low recoveries for sample DCD-SB-28-06-10 were due to matrix interference. At Parsons’ request, the laboratory provided a “blow-up” of the chromatogram and supporting information. The chromatogram showed a large non-target, early eluting peak. It appears that this peak suppressed the response for the non-compliant surrogates. All target analytes associated with the failing surrogates were non-detect, so all results were flagged “UJ” as estimated due to the possible low bias in sample DCD-SB-28-06-10. The chromatogram for sample DCD-SB-28-02-15 was inspected and showed significant interference from a multi-component, late-eluting hydrocarbon. The baseline demonstrated significant elevation over the majority of the chromatogram. All target analytes were non-detect in the sample or were detected at a concentration below the LOQ and thus were already qualified “J” with one exception. The sample contained chrysene at a concentration above the LOQ. Chrysene was qualified “J+” in sample DCD-SB-28-02-15 due to the possible high bias demonstrated by the surrogate recoveries and matrix interference.

4.2.2 MS/MSD Samples

Matrix spike / matrix spike duplicate samples were collected at the required frequency. Four MS/MSD pair were collected for 65 normal environmental soil samples. Matrix accuracy was evaluated using the MS/MSD recoveries. All MS/MSD recoveries were within acceptance criteria for explosives.

All MS and MSD spike recoveries were within acceptance criteria for VOCs, except for the following:

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SB-28-06-05	1,1,2,2-Tetrachloroethane	145	(110)	55-130%
	1,2,3-Trichlorobenzene	56	(69)	60-135%
	1,2,3-Trichloropropane	164	(120)	65-130%
	1,2,4-Trichlorobenzene	60	(75)	65-130%
	1,2-Dibromo-3-chloropropane	156	(119)	40-135%
	2-Chlorotoluene	132	(115)	70-130%
	4-Chlorotoluene	129	(117)	75-125%
	Acetone	226	178	20-160%
	Bromobenzene	122	(108)	65-120%
	Bromoform	138	(112)	55-135%
	Isopropylbenzene	133	(113)	75-130%

() indicates the recovery met criteria.

No corrective action was deemed necessary since the non-compliant analytes (with the exception of acetone) met criteria in the MSD and were only slightly (5-percent or less) below criteria in the MS or were recovered high in the MS and were non-detect in the parent sample. Acetone was recovered high in the MS and MSD and was non-detect in the parent sample, so data quality was not affected and no qualifiers were applied.

It should be noted that the MS/MSD samples from the initial sampling event (parent samples DCD-SO-28-20 and DCD-SO-28-30) were not spiked for benzyl alcohol or n-nitrosodimethylamine due to laboratory error. However, the MS/MSD samples were properly spiked with all target compounds for the follow-on sampling event conducting in October 2013. Three parent samples demonstrated non-complaint MS/MSD recoveries for SVOCs, as follows:

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SO-28-20	4,6-Dinitro-2-methylphenol	19	16	30-135%
	2,4-Dinitrophenol	13	12	15-130%

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SO-28-20 (Continued)	Hexachlorocyclopentadiene	(43)	32	38-107%
	n-Nitrosodiphenylamine	120	118	50-115%
DCD-SO-28-30	n-Nitrosodiphenylamine	116	(112)	50-115%
DCD-SB-28-06-05	n-Nitrosodiphenylamine	130	135	50-115%

() indicates the recovery met criteria.

No corrective action was necessary for n-nitrosodiphenylamine since the MS and/or MSD recoveries were high and the associated parent sample results were non-detect. Thus, data quality was not affected by the slight high bias demonstrated. The results for 4,6-dinitro-2-methylphenol, 2,4-dinitrophenol, and hexachlorocyclopentadiene were qualified "UJ" in parent sample DCD-SO-28-20 due to the low bias demonstrated by the MS/MSD pair.

N-nitrosodiphenylamine demonstrated a high bias in three of the four MS/MSD pair analyzed for SVOCs, demonstrating a potential systematic high bias. The potential high bias would increase the possibility of false positives. However, all sample results for this analyte were non-detect. Thus data usability was not affected and no additional corrective action was necessary.

Accuracy for metals demonstrated a similar level of heterogeneity as metals precision. All MS/MSD pair had several failing metals, as follows:

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SO-28-20	Aluminum	638	673	80-120%
	Antimony	54	52	
	Barium	157	163	
DCD-SO-28-20 (Continued)	Beryllium	126	122	80-120%
	Calcium	3179	2554	
	Iron	302	305	
	Lead	122	122	
	Magnesium	235	245	
	Manganese	137	150	
	Potassium	239	247	
	Sodium	121	122	

The parent sample concentrations for aluminum, calcium, iron, and magnesium were significantly greater than (more than seven times) the amount spiked, resulting in the anomalous recoveries. Since the spike could not be properly evaluated for these metals, no qualifiers were

applied for these metals as a result of the non-compliant recoveries. No corrective action was deemed necessary for lead or sodium since these metals were only slightly (2-percent or less) outside criteria. Antimony was detected in the parent sample at a concentration below the LOQ and thus was already flagged “J”. All other non-compliant metals were qualified “J+” due to the high MS/MSD recoveries.

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SO-28-30	Aluminum	562	566	80-120%
	Antimony	79	72	
	Arsenic	127	(119)	
	Barium	138	144	
	Beryllium	132	132	
	Calcium	4708	5991	
	Chromium	121	(119)	
	Iron	239	362	
	Lead	126	129	
	Magnesium	908	281	
	Manganese	285	223	
	Potassium	199	217	
	Sodium	127	(120)	
	Thallium	(120)	122	
	Vanadium	126	125	

The parent sample concentrations for aluminum, calcium, iron, and magnesium were significantly greater than (more that seven times) the amount spiked, resulting in the anomalous recoveries. Since the spike could not be properly evaluated for these metals, no qualifiers were applied for these metals as a result of the non-compliant recoveries. No corrective action was deemed necessary for chromium or thallium since these metals were only slightly (2-percent or less) outside criteria. Antimony was detected in the parent sample at a concentration below the LOQ and thus was already flagged “J”. All other non-compliant metals were qualified “J+” due to the high MS/MSD recoveries.

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SB-28-02-25	Aluminum	350	298	80-120%
	Antimony	(80)	78	
	Calcium	1590	0	
	Iron	164	29	

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SB-28-02-25 (Continued)	Magnesium	308	0	
	Manganese	130	182	
	Potassium	154	143	

() indicates the recovery met criteria.

The parent sample concentrations for aluminum, calcium, iron, and magnesium were significantly greater than (more that seven times) the amount spiked, resulting in the anomalous recoveries. Since the spike could not be properly evaluated for these metals, no qualifiers were applied for these metals as a result of the non-compliant recoveries. No corrective action was deemed necessary for antimony since this metal met criteria in the MS and was only slightly (2-percent) outside criteria in the MSD. All other non-compliant metals were qualified “J+” due to the high MS/MSD recoveries.

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SB-28-04-20	Aluminum	680	846	80-120%
	Antimony	38	39	
	Calcium	0	0	
	Iron	414	491	
	Magnesium	303	274	
	Manganese	141	163	
	Potassium	230	271	

The parent sample concentrations for aluminum, calcium, iron, and magnesium were significantly greater than (more that seven times) the amount spiked, resulting in the anomalous recoveries. Since the spike could not be properly evaluated for these metals, no qualifiers were applied for these metals as a result of the non-compliant recoveries. The parent sample was non-detect for antimony so the result for this metal was qualified “UJ”. All other non-compliant metals were qualified “J+” due to the high MS/MSD recoveries.

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SB-28-06-05	Aluminum	272	428	80-120%
	Antimony	66	61	
	Calcium	1166	4941	
	Copper	(115)	122	
	Iron	676	220	
	Lead	(109)	64	

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SB-28-06-05 (Continued)	Magnesium	490	313	
	Manganese	267	326	
	Potassium	129	143	
	Zinc	494	(100)	

() indicates the recovery met criteria.

The parent sample concentrations for aluminum, calcium, iron, and magnesium were significantly greater than (more than seven times) the amount spiked, resulting in the anomalous recoveries. Since the spike could not be properly evaluated for these metals, no qualifiers were applied for these metals as a result of the non-compliant recoveries. No corrective action was deemed necessary for copper since this metal met criteria in the MS and was only slightly (2-percent) outside criteria in the MSD. The parent sample was non-detect for antimony so the result for this metal was qualified “UJ”. Manganese and potassium were qualified “J+” due to the high MS/MSD recoveries. Lead and zinc were qualified “J” as estimated since the MS/MSD demonstrated variability, but no clear bias.

Manganese and potassium are the only metals that demonstrated a potential high bias in all five MS/MSD pair. All soil sample results for manganese were significantly below (approximately one half) the project action limit, so data usability was not adversely affected by the potential high analytical bias. The project does not have an action limit for potassium, so the potential high bias for this metal did not impact data usability.

Mercury met criteria in all but one of the MS/MSD samples, as follows:

Sample ID	Analyte	MS %R	MSD %R	Criteria
DCD-SO-28-30	Mercury	(114)	124	80-120%

() indicates the recovery met criteria.

Mercury was detected in the parent sample at a concentration below the LOQ and thus was already qualified “J”, so no corrective action was necessary.

4.2.3 LCS/LCSD Samples

All LCS and LCSD spike recoveries were within acceptance criteria for VOCs, explosives, metals, and mercury. Thus analytical accuracy was well controlled for this data set.

Due to a laboratory error, the SVOC LCS samples associated with SDG 160-1775 were not spiked for benzyl alcohol or n-nitrosodimethylamine. The accuracy of these compounds was evaluated using the ICV and CCV recoveries. Accuracy was well controlled in the ICV and CCV samples for these analytes with the exception noted in the following section. Therefore, qualification of the data was not deemed necessary. The error was brought to the laboratory's attention to ensure that all future analytical data will be reported with the proper spike. The error was corrected prior to the follow-on investigation in October 2013. Therefore the data in SDGs 160-4130 and 160-4138 were not affected.

Hexachlorocyclopentadiene and n-nitrosodiphenylamine demonstrated a high analytical bias in the LCS samples for SVOC from initial sampling event, as follows:

Batch	Analyte	LCS %R	Criteria
41090	Hexachlorocyclopentadiene	129	38-107%
	n-Nitrosodiphenylamine	116	50-115%
41092	Hexachlorocyclopentadiene	138	38-107%
	n-Nitrosodiphenylamine	119	50-115%

Both analytes were recovered high and were non-detect in all associated samples. Therefore, data quality was not affected by the high bias and no data qualifiers were applied. Based on data collected during March 2013 at SWMU 28 and several other SWMUs at TEAD-S, a systematic analytical high bias was identified for these compounds. Review of the laboratory control charts for these analytes confirmed the high bias with all data points falling above the mean recovery for the time period samples associated with SDG 160-1775 were being analyzed. At Parsons' request, the laboratory investigated the high recoveries for these compounds and determined that the initial calibration standard was biased low, resulting in a high analytical bias for hexachlorocyclopentadiene and n-nitrosodiphenylamine. Data quality was not adversely affected, as all sample results for these analytes were non-detect. The bias introduced by the calibration standard would have increased the possibility of false positive results for these analytes, but as all sample results were non-detect, the data was considered usable without qualification. The laboratory purchased a new standard for these analytes and recalibrated the instruments on June 1, 2013. Control charts produced since the new standard was implemented show the analytical system is back in control.

For the October 2013 sampling (SDGs 160-4130 and 160-4138), all LCS recoveries were within criteria for SVOCs, except for the following:

Batch	Analyte	LCS %R	Criteria
80767	2,2'-Oxybis(1-chloropropane)	119	20-115%

The non-compliant analyte was recovered high and was non-detect in all associated samples. Therefore, data quality was not affected by the high bias and no data qualifiers were applied.

All LCS/LCSD recoveries were within acceptance criteria for the soil gas data.

4.2.4 ICV/CCV Samples

Initial and continuing calibration verification samples were analyzed at the required frequency. All ICV and CCV recoveries were within acceptance criteria for explosives, metals, and mercury. All ICV and CCV recoveries were within acceptance criteria for VOCs with the following exceptions:

Spike	Inst & Date	Analyte	%R	Criteria
ICV	MSX 10/10/13	Hexachlorobutadiene	148	80-120%
CCV	MSX 10/19/13	1,2-Dibromo-3-chloropropane	127	80-120%

Both analytes were recovered high and all associated samples were non-detect. Therefore, data quality was not affected by the high bias and no corrective action was necessary.

For the initial sampling event (March 2013), all SVOC ICV and CCV recoveries met criteria, except for the following:

Spike	Inst & Date	Analyte	%R	Criteria
ICV	MSJ 3/11/13	Hexachlorocyclopentadiene n-Nitrosodiphenylamine	159 126	80-120%

Both analytes were recovered high and all associated samples were non-detect. Therefore, data quality was not affected by the high bias and no corrective action was necessary.

Hexachlorocyclopentadiene and n-nitrosodiphenylamine demonstrated a high analytical bias for the initial sampling event (March 2013). The ICV is prepared using a second source standard and further confirmed the systematic high bias for hexachlorocyclopentadiene resulting from the initial calibration standard. Data quality was not adversely affected, as all sample results

for hexachlorocyclopentadiene and n-nitrosodiphenylamine were non-detect. The high ICV bias would have increased the possibility of false positive results for these analytes, but as all water sample results were non-detect, the data was considered usable without qualification.

For the follow-on sampling event (October 2013), all SVOC ICV and CCV recoveries met criteria, except for the following:

Spike	Inst & Date	Analyte	%R	Criteria
ICV	MSI 10/23/13	1,4-Dioxane	124	80-120%
		n-Nitrosodimethylamine	129	
		Pyridine	122	
		2,2'-Oxybis(1-chloropropane)	137	
ICV	MSJ 10/24/13	2,2'-Oxybis(1-chloropropane)	141	80-120%
ICV	MSK 10/24/13	2,2'-Oxybis(1-chloropropane)	140	80-120%
CCV	MSI 10/24/13	n-Nitrosodimethylamine	123	80-120%

All non-compliant analytes were recovered high and all associated samples were non-detect. Therefore, data quality was not affected by the high bias and no corrective action was necessary. The laboratory was contacted regarding the systematic bias demonstrated for 2,2'-oxybis(1-chloropropane). The laboratory was aware of the issue and indicated the anomalous recoveries were due to a split in the chromatographic peak for this compound. The larger peak has an ion spectra that matches 2,2'-oxybis(1-chloropropane). The smaller peak ion spectra shows that it contains a mixture of the primary analyte as well as two isomers (1,1-oxybis[1-chloropropane] and 1,1-oxybis[3-chloropropane]). The analyst excluded the smaller peak from the integration of 2,2-oxybis(1-chloropropane) in the ICAL, resulting in the anomalous second source (ICV) recoveries. The laboratory is working with the standard vendor to determine if the smaller peak is an impurity in the standard or if it represents a breakdown product of 2,2-oxybis(1-chloropropane). A new standard has been ordered by the laboratory and will be evaluated upon receipt.

All ICV and CCV recoveries were within acceptance criteria for soil gas.

4.2.5 Internal Standards

All sample and QC results for VOCs, SVOCs, and metals were quantitated against internal standards. All internal standard recoveries were within acceptance criteria with the

exception of a single VOC batch. Internal standards were recovered high in most samples in volatiles batch 80399 analyzed on October 19, 2013, as follows:

Sample	Internal Std	AC	Minimum AC
DCD-SB-28-05-10	1,4-Dichlorobenzene-d4	297674	360604
DCD-SB-28-06-05	1,4-Dichlorobenzene-d4	246893	360604
DCD-SB-28-06-05MS	1,4-Dichlorobenzene-d4	346513	360604
DCD-SB-28-06-05FD	1,4-Dichlorobenzene-d4	331737	360604
DCD-SB-28-06-10	1,4-Dichlorobenzene-d4	291721	360604
DCD-SB-28-06-15	1,4-Dichlorobenzene-d4	317624	360604
DCD-SB-28-06-20	1,4-Dichlorobenzene-d4	335499	360604
DCD-SB-28-06-25	1,4-Dichlorobenzene-d4	345674	360604
DCD-SB-28-07-05	1,4-Dichlorobenzene-d4	353471	360604
DCD-SB-28-07-10	1,4-Dichlorobenzene-d4	274916	360604
DCD-SB-28-07-15	1,4-Dichlorobenzene-d4	352887	360604
DCD-SB-28-07-20	1,4-Dichlorobenzene-d4	354622	360604
DCD-SB-28-07-20FD	1,4-Dichlorobenzene-d4	358207	360604
DCD-SB-28-07-25	1,4-Dichlorobenzene-d4	298998	360604

A low internal standard area count results in a high analytical bias. All non-compliant internal standards were recovered low and all associated target VOCs were non-detect. Therefore, data was not affected by the high bias, and no data qualifiers were applied. It should be noted that the surrogate 4-bromofluorobenzene is quantitated against the internal standard 1,4-dichlorobenzene-d4 and the high bias for this surrogate was demonstrated in the associated samples, as detailed in Section 4.2.1. All other internal standard recoveries for the samples from SWMU 28 were within acceptance criteria. The consistently low area counts for 1,4-dichlorobenzene-d4 in the single analytical batch for volatiles indicates a likely spiking error. The standard used may have been improperly prepared or slightly degraded, resulting in the low recoveries. It further indicates that matrix was most likely not the cause of the failing internal standards. As this appears to be an isolated spiking issue, no additional corrective action was deemed necessary.

4.2.6 Post Digestion Spike

The laboratory analyzed a post digestion spike (PDS) in each batch as required. The PDS samples performed on samples unrelated to this project were not evaluated. The PDS samples

were applicable for all metals except those that met criteria in the associated dilution test. All applicable metals met criteria in the post digestion spikes performed on samples from SWMU 28 with the following exceptions:

Sample	Metal	%D	Criteria
DCD-SO-28-18	Aluminum	0	75-125%
	Copper	31	
	Iron	0	
	Lead	72	
	Magnesium	0	
	Manganese	0	
	Nickel	70	
	Potassium	0	
	Sodium	69	
	Zinc	58	
DCD-SO-28-30FD	Barium	0	75-125%
	Copper	23	
	Lead	60	
	Nickel	73	
	Sodium	73	
	Zinc	53	

All metals that failed to meet criteria in the PDS were qualified “J” as estimated in the associated parent sample, in accordance with the QAPjP (Parsons, 2013a). As previously noted, the samples in this data set demonstrated significant heterogeneity with respect to metals. However, no systematic trends were identified for specific metals, so no additional corrective action was deemed necessary.

4.3 REPRESENTATIVENESS

Representativeness is controlled by using standard sampling techniques, adhering to the required preparation and analytical holding times, maintaining proper sample storage temperatures, the evaluation of laboratory blanks, and through the collection of field blanks. Representativeness was well controlled for this data set and other than blank contamination, no significant issues were found.

4.3.1 Sampling Techniques

All samples were collected by Parsons in accordance with the procedures detailed in the DoD (2010) QSM and the project QAPjP (Parsons, 2013a). Samples were collected at all planned locations and depths identified during the project planning stage. VOC samples were collected using triplicate 5-gram EnCore™ samplers. Certified-clean and pre-preserved (as required) sampling containers were provided by the laboratory for this sampling event. All soil gas samples were collected by Parsons using certified-clean 1-liter SUMMA® canisters provided by the laboratory. Strict chain-of-custody procedures were followed both in the field and at the laboratory. Daily field reports were produced to document site conditions, personnel, sample collection, and custody. All samples were in the custody of the field crew until surrendered to FedEx for shipment to the laboratory. The daily field reports for this project are provided in Appendix A.

4.3.2 Holding Times

All samples were prepared and analyzed within the holding times required by the DoD (2010) QSM and the project QAPjP (Parsons, 2013a).

4.3.3 Sample Storage Temperatures

All samples were put on ice immediately following collection, with the exception of the soil gas samples which do not require temperature preservation. All samples were shipped to the laboratory in the provided coolers or containers. All coolers were received by the laboratory at temperatures within the acceptance criteria of 0.1° to 6.0° Celsius. Samples were properly stored at the required temperatures at the laboratory throughout the preparation and analytical process.

4.3.4 Laboratory Blanks

Laboratory method blanks were prepared and analyzed at the frequency required by the DoD (2010) QSM and the project QAPjP (Parsons, 2013a). All target VOCs were non-detect in the soil laboratory method blanks. All target VOCs were non-detect in the water method blanks, with one exception. The water method blank associated with the VOC trip blanks and equipment blank contained acetone at a concentration of 1.45 micrograms per liter (µg/L) below the LOQ of 2.0 µg/L. Acetone was detected in the equipment blank at a concentration greater than ten times the method blank result, so no corrective action was necessary for the equipment blank. Acetone was detected in DCD-TB-28-01 at a concentration below the LOQ and the result was changed to

non-detect at the LOQ due to the method blank contamination. Acetone was detected in DCD-TB-28-02 at a concentration slightly above the LOQ and within ten times the method blank concentration. The acetone result in sample DCD-TB-28-02 was changed to non-detect at the concentration found due to the method blank contamination.

All method blanks associated with the SVOC, explosives, and mercury analyses were non-detect. All water method blanks were non-detect for metals, except for the following:

Blank ID	Analyte	Conc. (µg/L)	LOQ (µg/L)
MB 160-79725/1-A	Antimony	4.97	5.0

The equipment blank result for antimony was below the LOQ and within five times the method blank concentration. Therefore, the equipment blank result for antimony was changed to non-detect at the LOQ due to the method blank contamination.

All soil laboratory method blanks were non-detect for metals, except for the following:

Blank ID	Analyte	Conc. (mg/Kg)	LOQ (mg/Kg)
MB 160-41371/1-A	Potassium	4.76	9.9
	Sodium	7.95	25
MB 160-80695/1-A	Silver	0.0274	0.20
MB 160-80696/1-A	Antimony	0.495	0.44
	Cadmium	0.0408	0.052
	Selenium	0.157	0.44
	Silver	0.0302	0.17
MB 160-80895/1-A	Copper	0.160	0.91
	Silver	0.0279	0.18

All associated soil sample results were either non-detect or detected at a concentration significantly greater than the amount found in the method blank for the metals listed above. Therefore, no corrective action was necessary as per the project QAPjP.

For soil gas, the laboratory method blank contained low-level detections of several VOCs, as follows:

Blank ID	Analyte	Conc. (ppbv)	LOQ (ppbv)
1304064-17A	1,2-Dichlorobenzene	0.16	0.50
	1,3-Dichlorobenzene	0.15	0.50
	1,4-Dichlorobenzene	0.17	0.50
	Bromomethane	0.31	5.0

Blank ID	Analyte	Conc. (ppbv)	LOQ (ppbv)
1304064-17A (Continued)	Chlorobenzene	0.082	0.50
	Methylene chloride	0.12	5.0
	Tetrachloroethene	0.073	0.50
	Toluene	0.039	0.50

All soil gas sample results for the VOCs detected in the laboratory method blank were changed to non-detect at the LOQ if the sample concentration was within five times the amount found in the method blank.

4.3.5 Field Blanks

Field blanks, including trip blanks, equipment blanks, and a source blank were collected at the frequency required by the project QAPjP (Parsons, 2013a). The results obtained are detailed below. Field blanks were not applicable to the TO-15 analysis of soil gas samples.

Trip blanks were included in every shipment that contained samples for volatiles analysis, as per the DoD (2010) QSM and project QAPjP (Parsons, 2013a). The trip blanks were non-detect for all target VOCs with the exception of acetone. Acetone was detected below the LOQ in trip blank DCD-TB-28-01 and just above the LOQ in trip blank DCD-TB-28-02. As previously noted, both trip blank results for acetone were changed to non-detect due to the acetone detection in the associated method blank.

Equipment blanks were collected at the proper frequency of every other day as required by the project QAPjP (Parsons, 2013a). Two equipment blanks were collected for the SWMU 28 sampling, one during the initial sampling event in March 2013 and one during the follow-on sampling event in October 2013. Equipment blank DCD-EB-19-01 was collected on March 12, 2013 and reported in SDG 160-1764. This EB was non-detect for all target analytes. Equipment blank DCD-EB-28-01 was collected on October 15, 2013 and was applicable to all samples collected during the follow-on event at SWMU 28. The equipment blank associated with the follow-on sampling was non-detect for all target SVOCs and mercury. The following VOCs and metals were detected in the equipment blank collected during the follow-on sampling event (October 2013):

Sample ID	Analyte	Conc. (µg/L)	LOQ (µg/L)
DCD-EB-28-01	2-Butanone (MEK)	2.7	5.0
	Acetone	24	2.0

Sample ID	Analyte	Conc. (µg/L)	LOQ (µg/L)
DCD-EB-28-01 (Continued)	Toluene	0.19	2.0
	m/p-Xylene	0.18	1.0
	Antimony	4.7	5.0
	Barium	0.28	2.0
	Cadmium	0.20	0.50
	Lead	0.23	3.0

The acetone detection in sample DCD-SB-28-03-10 was below the LOQ and thus was changed to non-detect at the LOQ due to the associated equipment blank detection. All other samples were non-detect for the VOC analytes detected in the equipment blank, so no additional corrective action was necessary. All metals detected in the equipment blank were either non-detect in the associated samples or detected at a concentration significantly greater than the EB result. Therefore, data quality was not affected and no corrective action was necessary for metals.

The source blank consisted of an aliquot of the laboratory-grade water to be used for equipment blanks into the appropriate sample containers. The source blank is used to identify contamination that is contributed by the laboratory provided water itself and not from the equipment used. One source blank was collected in association with the SWMU 28 samples in this data set. The source blank was non-detect for all target SVOCs and mercury. The following VOCs were detected in the source blank:

Sample ID	Analyte	Conc. (µg/L)	LOQ (µg/L)
DCD-SB-19/28-01	2-Butanone (MEK)	4.6	5.0
	Acetone	16	2.0
	Methylene chloride	0.44	1.0

The contamination found in the equipment blanks was attributed to the water provided by the laboratory due to the similarity of the source blank detections. The equipment blank results for 2-butanone was changed to non-detect at the LOQ due to the source blank contamination. Acetone was changed to non-detect at the concentration found in the equipment blank due to the source blank contamination. No additional corrective action was necessary.

The following metals were detected in the source blank:

Sample ID	Analyte	Conc. (µg/L)	LOQ (µg/L)
DCD-SB-19/28-01	Silver	0.39	2.0
	Sodium	16	50
	Thallium	0.66	2.0

All associated sample results were either non-detect or detected at a concentration significantly greater than the source blank result for all metals listed in the table above. Therefore, data quality was not affected and no corrective action was necessary.

4.4 COMPARABILITY

Comparability of sample results is ensured through the use of approved sampling, preparation, and analysis methods using standardized equipment, reporting conventions and units. Comparability was well controlled for this data set.

4.4.1 Sampling

Samples were collected using the methodologies detailed in the DoD (2010) QSM and the project QAPjP (Parsons, 2013a). Trained and experienced Parsons staff collected samples using certified-clean sampling containers supplied by the laboratory. All non-dedicated sampling equipment was properly decontaminated. Samples were collected in a manner that preserved the composition of the soil core.

Trained and experienced staff at the laboratory performed subsampling from soil jars in accordance with standardized laboratory procedures. Subsamples were collected in a manner that preserved the composition of the soil sample to the extent possible.

4.4.2 Preparation and Analysis

Standardized SW-846 preparation and analytical methods were used, as detailed in the DoD (2010) QSM and the project QAPjP (Parsons, 2013a). The laboratories hold current NELAP and Utah State certifications for the methods performed. The laboratories use standardized and certified equipment and instrumentation at or above the level required by the associated preparation and analytical methods. All instruments were properly calibrated prior to analysis.

4.4.3 Reporting Conventions

Standardized reporting conventions and units were used as required by the project QAPjP (Parsons, 2013a). The laboratory limit of detection (LOD) and LOQ values matched those required by the QAPjP, with sample-specific preparation and analytical factors taken into account.

4.5 COMPLETENESS

Completeness is calculated by analyte, method, and data set and is a quantitative expression of the data usability based on the number of rejected data. For this project, the minimum completeness for each analyte, method, and data is 95-percent. The completeness calculation considers all data that is not rejected to be usable and is calculated as follows:

$$\text{Percent Completeness} = \frac{\text{Number of Usable Results}}{\text{Total number of results}} \times 100$$

No data was rejected based on the data review detailed above. All data points were considered usable, including those qualified “U”, “UJ”, “J”, “J-”, and “J+”. Therefore, the percent completeness for each analyte and method was 100-percent, and the overall completeness for this data set was 100-percent.

4.6 DATA QUALITY CONCLUSIONS / DATA USABILITY

Data usability was evaluated using a multi-disciplinary team, and was based on the data review, data quality requirements, and ultimate use of the data. Data usability was evaluated for the dataset as a whole, as well as for each sample and each preparation / analytical batch. This section identifies the data quality issues found and their impact on the usability of the data for making the project decisions outlined in the data quality objectives.

4.6.1 Volatile Organic Compounds (VOCs)

The quality issues found for the volatiles data included failing surrogate recoveries, failing internal standards, non-compliant MS/MSD recoveries, and ICV/CCV failures. Each of these issues had minimal impact on data usability. No qualifiers were applied to the VOC data as a result of the minor exceedances noted. Thus, no limitations on the data usability resulted from the data quality issues.

4.6.2 Semivolatile Organic Compounds (SVOCs)

The data quality issues found for the SVOC data included ICV/CCV failures, MS/MSD RPD failures, a single field duplicate RPD failure, and two samples with non-compliant surrogates. In addition, three systematic issues were found for the water SVOC data. These included a systematic high bias for two compounds (hexachlorocyclopentadiene and n-nitrosodiphenylamine) and compounds missing from the LCS and MS/MSD spikes for the initial sampling event (March 2013), and a high bias for 2,2'-oxybis(1-chloropropane) for the follow-on sampling event (October 2013). Each quality issue found for SVOCs and the impact on the usability of the data for making project decisions is detailed below.

Hexachlorocyclopentadiene and n-nitrosodiphenylamine demonstrated a systematic high analytical bias for this dataset. As discussed in Section 4.2, these analytes were recovered high in both SVOC LCS/LCSD pair and the ICV associated with the initial sampling event. In addition, n-nitrosodiphenylamine was recovered high in three of the four MS/MSD pair associated with the SWMU 28 event. Thus, the data demonstrated a systematic high analytical bias for these compounds. The analytical bias would have increased the possibility of false positive results for this analyte; however, all results were non-detect and data quality was not adversely affected. Therefore, all data for hexachlorocyclopentadiene and n-nitrosodiphenylamine was considered usable without qualification. No limitations on the data usability resulted from these systematic issues.

Due to laboratory error, the spike solution used for the LCS/LCSD and MS/MSD samples associated with the initial sampling event (March 2013) did not contain benzyl alcohol or n-nitrosodimethylamine. The required analyte lists were communicated to the laboratory prior to sampling. Parsons brought the issue of the incorrect spike solution to the attention of the laboratory quality assurance (QA) officer. It was determined that the laboratory project manager had failed to note the correct spiking requirements in the project profile and this error was corrected prior to the follow-on sampling at SWMU 28. Both benzyl alcohol and n-nitrosodimethylamine were properly calibrated and met criteria in the second source ICV sample and the batch CCV samples. In addition, the DoD (2010) QSM only requires a minimum of 16 analytes be spiked for methods with 20 or more target analytes. Since 77 target analytes were reported for the water SVOC analyses and all but two analytes were included in the LCS/LCSD and MS/MSD samples, the effect on data quality was minimal. All sample and QC results for

1 these compounds were non-detect, so decision-making was not affected and all data was
2 considered usable. The field duplicate results were used to evaluate precision for benzyl alcohol
3 and n-nitrosodimethylamine. While these two analytes were non-detect in both the parent and
4 field duplicate samples, reproducibility of results, whether detect or non-detect is a measure of
5 precision. In addition, Worksheet #37 of the TEAD-S QAPP states, “*An analyte may have been*
6 *included in a standard analytical suite although no site history suggests its presence, and a*
7 *problem with this analyte may represent a tolerable uncertainty.*” Since only two analytes of the
8 77 analyzed in the SVOC were affected, the lack of LCS/LCSD and MS/MSD precision for the
9 initial sampling at SWMU 28 (March 2013) represents a tolerable uncertainty for the event.

10 All non-compliant ICV/CCV recoveries appeared to be random sporadic failures with the
11 exception of 2,2-oxybis(1-chloropropane). The ICV and LCS failures for this compound
12 indicated a systematic high bias for this compound. Since the high bias increases the possibility
13 of false positives and all associated sample results were non-detect for this analyte, data quality
14 was not adversely affected and no limitations on data usability resulted from the systematic bias.
15 The laboratory was contacted regarding the high bias for this analyte. The laboratory indicated
16 that the peak for this compound is split in the ICAL standard. A review of the ions present in the
17 smaller peak shows that it contains a mixture of the target analyte and two additional isomers.
18 As such, the analyst excluded the smaller peak from the integration. The laboratory ordered a
19 new standard and has recalibrated the instrumentation. The laboratory continues to work with
20 the vendor to resolve the issue.

21 Several MS/MSD RPDs exceeded criteria as noted above. However, the variability
22 demonstrated did not affect data quality as all sample results were non-detect for the affected
23 analytes. With the exception of n-nitrosodimethylamine, the non-compliant analytes were
24 reported as non-detect at concentrations significantly below the associated action limit.
25 Therefore, even taking into account the variability demonstrated by the MS/MSD RPDs, the
26 sample-specific non-detect concentrations were lower than the action limits to such an extent that
27 no limitations on data usability resulted. For n-nitrosodimethylamine, the laboratory LOD
28 exceeded the project action limit of 0.0023 mg/kg, as noted in the project QAPjP. The analyte n-
29 nitrosodimethylamine has been rarely detected at TEAD-S, and it is not anticipated to be present
30 based on site history. Therefore, the level of sensitivity associated with this SVOC does not

1 represent a data gap. The elevated LOD did not affect the conclusions of the risk assessment
2 (Section 6.0).

3 One field duplicate pair demonstrated significant variability for bis(2-
4 ethylhexyl)phthalate, resulting in two “J” qualified results. The higher of the two reported values
5 was used for statistical analysis since this approach is more conservative with respect to the
6 environment. Even with the variability demonstrated in the single non-compliant field duplicate
7 pair, the highest detected concentration for bis(2-ethylhexyl)phthalate was 2.2 µg/L and was
8 significantly lower than the action level of 35 µg/L. Therefore, no limitations on data usability
9 resulted from the high field duplicate RPD.

10 Two samples demonstrated non-compliant surrogate recoveries that resulted in qualified
11 data. The surrogates 2-fluorobiphenyl and 2,4,6-tribromophenol were recovered low in sample
12 DCD-SB-28-06-10 resulting in “UJ” qualifiers for the following analytes: acenaphthene,
13 acenaphthylene, atrazine, azobenzene, 1,1-biphenyl, 4-bromophenyl phenyl ether, caprolactam,
14 2-chloronaphthalene, 4-chlorophenyl phenyl ether, dibenzofuran, diethyl phthalate, dimethyl
15 phthalate, 2,4-dinitrophenol, 2,4-dinitrotoluene, 2,6-dinitrotoluene, fluorene, hexachlorobenzene,
16 hexachlorocyclopentadiene, 2-methylnaphthalene, 2-nitrotoluene, 3-nitroaniline, 4-nitroaniline,
17 4-nitrophenol, n-nitrosodiphenylamine, pentachlorophenol, 1,2,4,5-tetrachlorobenzene, 2,3,4,6-
18 tetrachlorophenol, 2,4,5-trichlorophenol, 2,4,6-trichlorophenol. For the qualified analytes, all
19 were non-detect at a concentration significantly lower than the associated action limit with the
20 exception of hexachlorobenzene and pentachlorophenol. For those analytes with action limits
21 significantly greater than (seven times or more) the associated LOD, data usability was not
22 affected by the low surrogate recoveries. For hexachlorobenzene and pentachlorophenol, the
23 associated action levels were approximately three times the LOD. These compounds were not
24 detected in any of the SWMU 28 samples and were not expected to be present at the site.
25 Therefore, while close to the action limit, the estimated non-detect values did not affect the
26 usability of the data for the purposes of this project, and these non-detect results with elevated
27 LODs did not affect the conclusions of the risk assessment (Section 6.0).

28 Four of the six spiked surrogates failed high in sample DCD-SB-28-02-15. The
29 chromatogram for this sample clearly demonstrated the presence of a multi-component
30 hydrocarbon that interfered with the quantitation of the four non-compliant surrogates. All target

SVOCs associated with the non-compliant surrogates were either non-detect or detected at a concentration below the LOQ and thus were already qualified “J”, with one exception. Chrysene was detected in the sample at a concentration above the LOQ and was qualified “J+” due to the possible high bias resulting from the matrix interference. The project action limit of 15 µg/L for chrysene was significantly greater than the detected concentration of 1.7 µg/L. Since the reported chrysene concentration was potentially biased high and was significantly lower than the project action level, the estimated concentration did not impact data usability.

Several analytes were reported as non-detect at a concentration that exceeded the project action level, as per the approved project QAPjP. Non-detects in soil samples for which the achievable analytical sensitivity did not meet the project action levels (i.e., USEPA (2013) residential soil RSLs) are shown in the table below:

Analyte	Result ¹ (mg/kg)	Project Action Limit ² (mg/kg)
Bis(2-chloroethyl)ether	<0.45	0.21
2,6-Dinitrotoluene	<0.45	0.33
n-Nitroso-di-n-propylamine	<0.45	0.069
3,3'-Dichlorobenzidine	<3	1.1
Benzidine	<1.5	0.0005
1,2-Dibromo-3-chloropropane	<0.008	0.0054

^{1/} Result = maximum LOD value

^{2/} Project Action Limit = USEPA (2013a) residential soil RSLs

These six SVOC analytes are rarely detected at TEAD-S, and are not associated with a specific site history which would support their presence at SWMU 28. Therefore, the non-detect results for these compounds at the noted level of analytical sensitivity are not considered a data gap. Therefore, usability of the data was not impacted and the non-detect results with elevated LODs did not affect the conclusions of the risk assessment (Section 6.0).

4.6.3 Explosives

No data quality issues were identified for explosives. All data was usable as reported.

4.6.4 Metals

The data quality issues found for the metals analyses included MS/MSD RPD failures, field duplicate RPD failures, serial dilution and post digestion spike failures.

The samples from SWMU 28 demonstrated significant heterogeneity for metals, resulting in non-compliant MS/MSD recoveries and RPDs and field duplicate RPDs. The laboratory noted that the samples consisted of a non-homogeneous mixture of soil and rock. Due to the relatively small sample size used for metals, the variability is more evident for this method. Multiple data points were qualified as estimated due to the variability demonstrated. For all metals except arsenic, the detected concentrations were significantly lower than the associated action levels. In addition, the highest detected concentrations were used to calculate risk as this approach is most conservative with respect to protection of the environment. Thus, for these metals, data usability was not affected by the variability demonstrated and no limitations were placed on the data. Arsenic was detected in all samples from SWMU 28 at a concentration greater than ten times the project action limit. However, as discussed in Section 5.0, only three out of 72 soil samples (surface and subsurface) had concentrations of arsenic that exceeded the respective background reference value of 35 mg/kg. Although the arsenic concentration in three soil samples were greater than the background reference value (35 mg/kg), arsenic concentrations from samples collected at the landfill are concluded to be representative of site background conditions.

4.6.5 Mercury

The only data quality issue found for the mercury analyses was a slightly high MSD recovery. The parent sample result for mercury was below the LOQ and thus was already qualified “J” as estimated. The project action limit for mercury was greater than 90 times the highest mercury detection. Therefore, even with the inherent variability present at concentrations below the LOQ, all mercury data was usable for project decision-making.

4.6.6 Volatiles in Soil Gas (TO-15)

The soil gas data had minor quality issues with precision for acetone and m/p-xylene. However, all data was considered usable as qualified. The variability demonstrated by the field duplicate pair did not affect data usability because the maximum detected value was used for risk assessment. This approach is most conservative with respect to protection of the environment. In addition, the highest detected concentration for acetone in the samples from this event was 260 ppbv and the project action limit for this compound in air is 130000 ppbv. For m/p-xylene, the highest detected concentration for this event was 9.4 ppbv and the project action limit for

1 m/p-xylene is 230 ppbv. Therefore, even while taking into account the variability associated
2 with the acetone results and potential variability demonstrated for m/p-xylene, all sample
3 concentrations for these analytes were significantly lower than the action level. Thus, all soil gas
4 data was usable for the purposes of this project.

4.6.7 Data Usability Conclusions

5 In conclusion, the limitations on the dataset as a result of quality control issues were
6 minor and did not impact the ability to make project decisions. Data qualifiers were applied as
7 required, but all data (including qualified data) was usable for the purposes of this project.

SECTION 5.0

NATURE AND EXTENT INVESTIGATION RESULTS

This section presents the results of the nature and extent investigation activities performed at SWMU 28. Field sampling activities performed were described previously in Section 3.0 and included soil and active soil gas sampling. The results represent additional environmental data that is to be amended to the overall SWMU 28 RFI dataset and related findings.

5.1 SURFACE SOIL FIELD OBSERVATIONS AND RESULTS

A total of 30 surface soil samples (i.e., 0-0.5 ft bgs) and three field duplicates were collected at the landfill. In the western portion of the landfill, near samples DCD-SO-28-01 through DCD-SO-28-10, small amounts of plastic debris and thin aluminum sheeting were encountered on the ground surface. No staining, odor, or other evidence of contamination was observed at any of the surface soil samples collected from the landfill. A summary of the soil analytical results is presented in Appendix D, Table D.1. Detections in surface soil samples consisted of select SVOCs and metals (Table 5.1). No explosives were detected in any of the surface soil samples. A total of 12 SVOCs were detected at low levels in one or more of the surface soil samples. Metals were detected in all surface soil samples.

For both surface and subsurface soils collected during the RFI, the following steps were used to determine whether adequate sampling was conducted:

1. Identifying inorganic compounds detected in site soils with concentrations above background reference values.
2. Determine which (if any) chemicals exceed corresponding USEPA (2013a) residential soil Regional Screening Levels (RSLs) for organic compounds and inorganic compounds identified in Step 1.
3. Use professional judgment (consisting of a review of site history; an evaluation of the magnitude, frequency, and spatial distributions of chemical concentrations) to determine if adequate soil sampling was conducted for the chemicals (if any) identified in Step 2.

Step 1 – Background Threshold Value Comparison

Twelve metals (antimony, cadmium, calcium, cobalt, iron, magnesium, mercury, nickel, selenium, silver, thallium, and zinc) detected in surface soils had maximum site concentrations

TABLE 5.1
SUMMARY STATISTICS FOR SURFACE SOIL SAMPLES (0-0.5 FT BGS) (mg/kg)
 RCRA Facility Investigation Addendum Report for SWMU 28
 Tooele Army Depot - South Area

Chemical	N	#D	%D	Min LOD ¹	Max LOD ¹	Min D	Max D	Background Reference Value ³	Exceeds Background?	Residential Soil RSL ⁴	Exceeds RSL?	Location of Max Detect
Inorganics												
Aluminum	33	33	100%	— ²	-	4,400	14,000	17,610	No	77,000	NE	DCD-SO-28-10
Antimony	33	33	100%			0.39	1.2	0.96	Yes	31	No	DCD-SO-28-27
Arsenic	33	33	100%	-	-	9	17	35	No	0.61	NE	DCD-SO-28-05 DCD-SO-28-06 DCD-SO-28-13
Barium	33	33	100%	-	-	52	210	239.8	No	15,000	NE	DCD-SO-28-10 DCD-SO-28-15
Beryllium	33	33	100%			0.37	0.96	0.97	No	160	NE	DCD-SO-28-19
Cadmium	33	33	100%	-	-	0.46	1.7	1.2	Yes ⁵	70	No	DCD-SO-28-27
Calcium	33	33	100%	-	-	87,000	280,000	121,000	Yes ⁶	ES	ES	DCD-SO-28-01
Chromium	33	33	100%	-	-	9.6	17	19.8	No	120000 ⁷	No	DCD-SO-28-10 DCD-SO-28-20FD
Cobalt	33	33	100%	-	-	2.6	8.7	5.7	Yes	23	No	DCD-SO-28-15
Copper	33	33	100%	-	-	9.4	20	32.4	No	3100	NE	DCD-SO-28-20FD
Iron	33	33	100%	-	-	8,200	18,000	15,460	Yes	55,000	No	DCD-SO-28-10
Lead	33	33	100%	-	-	15	30	39.3	No	400	NE	DCD-SO-28-20FD
Magnesium	33	33	100%	-	-	8,600	33,000	17,240	Yes ⁶	ES	ES	DCD-SO-28-08
Manganese	33	33	100%	-	-	230	560	698.7	No	1800	NE	DCD-SO-28-05
Mercury	33	33	100%	-	-	0.019	0.065	0.05	Yes	10	No	DCD-SO-28-29
Nickel	33	33	100%	-	-	10	23	14.5	Yes	1500	No	DCD-SO-28-27
Potassium	33	33	100%	-	-	1300	5,200	9,131	No	ES	NE	DCD-SO-28-02 DCD-SO-28-05
Selenium	33	33	100%	-	-	0.94	2.6	1.4	Yes	390	No	DCD-SO-28-26
Silver	33	33	100%	-	-	0.15	0.61	NA	NA	390	No	DCD-SO-28-09
Sodium	33	33	100%	-	-	88	240	581.4	No	ES	NE	DCD-SO-28-10
Thallium	33	33	100%	-	-	0.18	0.53	NA	NA	0.78	No	DCD-SO-28-19
Vanadium	33	33	100%	-	-	14	27	27.94	No	390	NE	DCD-SO-28-10
Zinc	33	33	100%	-	-	39	100	77.1	Yes ⁵	23,000	No	DCD-SO-28-12

TABLE 5.1
SUMMARY STATISTICS FOR SURFACE SOIL SAMPLES (0-0.5 FT BGS) (mg/kg)
RCRA Facility Investigation Addendum Report for SWMU 28
Tooele Army Depot - South Area

Chemical	N	#D	%D	Min LOD ¹	Max LOD ¹	Min D	Max D	Background Reference Value ³	Exceeds Background?	Residential Soil RSL ⁴	Exceeds RSL?	Location of Max Detect
Semi-Volatile Organic Compounds												
Benzo(a)anthracene	33	8	24%	0.11	0.12	0.04	0.17	NA	NA	0.15	Yes	DCD-SO-28-24
Benzo(a)pyrene	33	7	21%	0.11	0.12	0.056	0.15	NA	NA	0.015	Yes	DCD-SO-28-24
Benzo(b)fluoranthene	33	9	27%	0.11	0.12	0.053	0.31	NA	NA	0.15	Yes	DCD-SO-28-24
Benzo(g,h,i)perylene	33	5	15%	0.11	0.12	0.051	0.12	NA	NA	1700 ⁸	No	DCD-SO-28-24
Benzo(k)fluoranthene	33	6	18%	0.11	0.12	0.048	0.12	NA	NA	1.5	No	DCD-SO-28-24
Chrysene	33	10	30%	0.11	0.12	0.04	0.29	NA	NA	15	No	DCD-SO-28-24
Dibenz(a,h)anthracene	33	1	3%	0.11	0.12	0.051	0.051	NA	NA	0.015	Yes	DCD-SO-28-24
Dimethylphthalate	33	14	42%	0.11	0.12	0.045	0.22	NA	NA	NA	NA	DCD-SO-28-14
Fluoranthene	33	8	24%	0.11	0.12	0.042	0.19	NA	NA	2300	No	DCD-SO-28-24 DCD-SO-28-11
Indeno(1,2,3-cd)pyrene	33	6	18%	0.11	0.12	0.045	0.12	NA	NA	0.15	No	DCD-SO-28-24
Phenanthrene	33	1	3%	0.11	0.12	0.066	0.066	NA	NA	3.6 ⁹	No	DCD-SO-28-11
Pyrene	33	7	21%	0.11	0.12	0.047	0.16	NA	NA	1700	No	DCD-SO-28-24

Notes:

- 1 The maximum and minimum LODs are presented to show the detection limit range for each detected analyte.
- 2 LOD not reported because chemical was detected in 100-percent of the samples.
- 3 AQS (2013). Final Risk Assumptions Document Solid Waste Management Units and Other Corrective Action Sites. Deseret Chemical Depot, Tooele, Utah. Revision 2. January.
- 4 USEPA (2013a). Residential Soil Regional Screening Level. May. <http://www.epa.gov/region9/superfund/prg/>.
- 5 Even though maximum detected concentration exceeds background reference value, site attribution found these analytes to be similar to background (Appendix F).
- 6 Even though maximum detected concentration exceeds background reference value, these analytes are essential nutrients.
- 7 No RSL available. Trivalent chromium used a surrogate.
- 8 No RSL available. Pyrene used a surrogate.
- 9 No RSL available. Naphthalene used a surrogate.

Definitions:

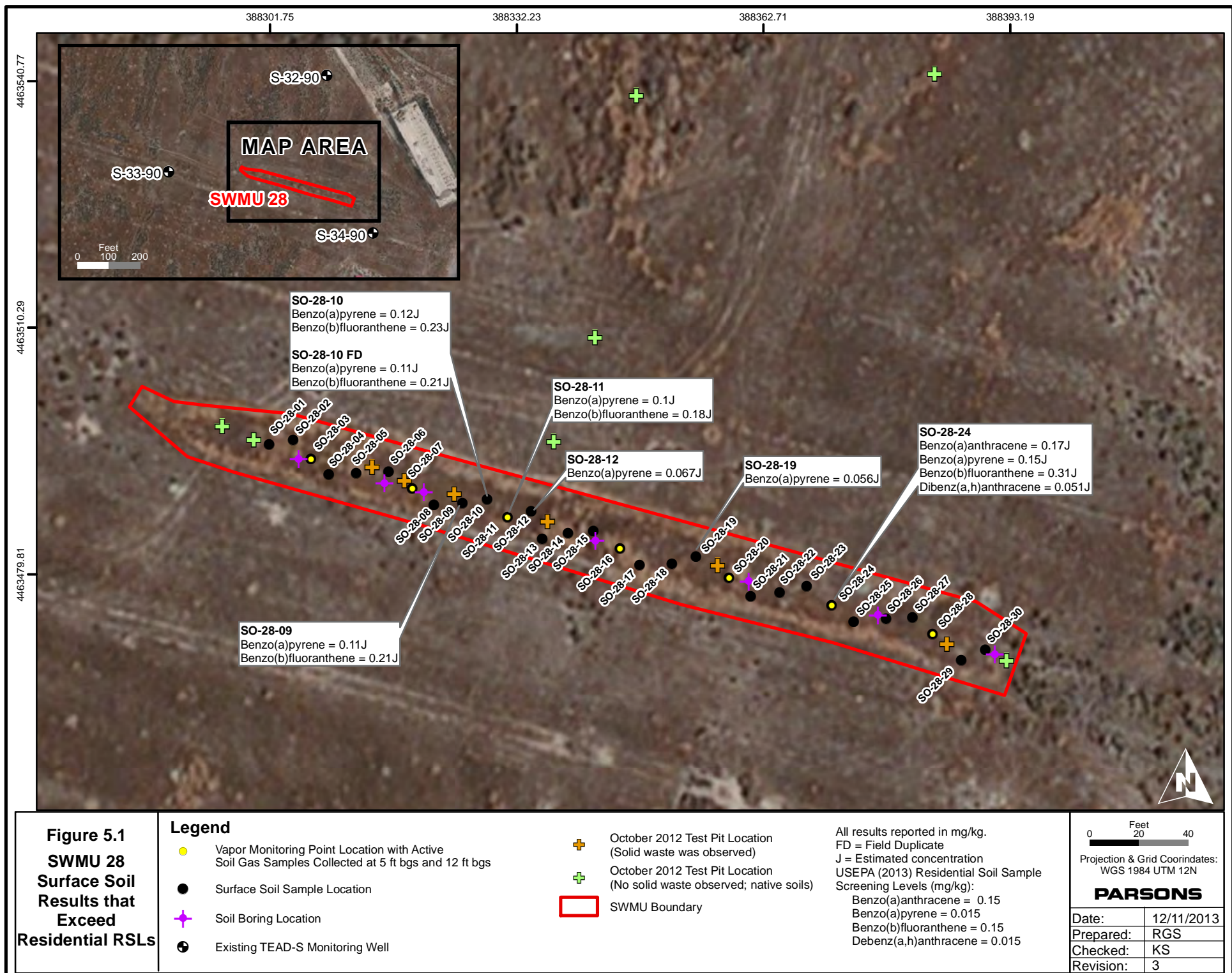
ES Essential nutrient	%D Percentage of detects
N Total number of samples analyzed	Min LOD Minimum limit of detection
NA Not available	Max LOD Maximum limit of detection
NE Not evaluated	Min D Minimum detected value
#D Number of detects	Max D Maximum detected value

greater than their corresponding background comparison values (or did not have TEAD-S background reference value). The background comparison evaluation is provided in Table 5.1. Although calcium and magnesium exceeded their respective background reference values, these analytes are classified as essential nutrients (USEPA, 1989). Essential human nutrients are toxic only at very high doses and therefore, calcium and magnesium were not carried forward to the subsequent steps and further characterization is not necessary for these essential nutrients.

For most of the remaining metals detected in surface soils with concentrations above background comparison values (antimony, cadmium, cobalt, iron, mercury, nickel, selenium, silver, thallium, and zinc), a formal site-attribution analysis was performed (Appendix F). The results of this site-attribution analysis show that cadmium and zinc are present at concentrations similar to background concentrations. Based on this analysis, no further characterization is required for these metals. The site-attribution analysis determined surface soil concentrations of cobalt, iron, and nickel do differ from background concentrations at TEAD-S, and therefore, cobalt and nickel were carried forward to the subsequent steps in this evaluation. Due to insufficient number of detections in the background data set, the site-attribution analysis was not conducted for antimony, mercury, and selenium; therefore, these analytes were retained for further analysis. No background value (or background data set) is available for silver and thallium; therefore, these two analytes were carried forward to the subsequent steps in this analysis.

Step 2 – Residential Soil RSL Comparison

Although future residential land use is not likely at this SWMU, maximum soil concentrations were conservatively compared with their corresponding USEPA (2013a) residential soil RSLs as one step in determining whether additional characterization of soils is required. The comparison to residential soil RSLs is presented in Table 5.1. Detected organic compounds and inorganic compounds carried forward from Step 1 were included in this evaluation (i.e., antimony, cobalt, iron, mercury, nickel, selenium, silver, and thallium). Only benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene had maximum detected concentrations in surface soil that were greater than their corresponding USEPA (2013a) residential soil RSLs. These four analytes were carried forward to Step 3 of this analysis. Locations of these exceedances are presented on Figure 5.1.



Step 3 – Professional Judgment

Benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were the only chemicals detected in surface soil samples in excess of their corresponding USEPA (2013a) residential RSL. As shown on Figure 5.1, benzo(a)anthracene and dibenz(a,h)anthracene were detected above respective residential soil RSLs only at one location (DCD-SO-28-24). At sample DCD-SO-28-24, the detected concentrations of benzo(a)anthracene (0.17J mg/kg) and dibenz(a,h)anthracene (0.051 mg/kg) were only slightly greater than their respective residential soil RSLs of 0.15 mg/kg and 0.015 mg/kg, respectively. Benzo(a)pyrene was detected above its respective residential soil RSL of 0.015 mg/kg in six surface soil samples and one associated field duplicate (DCD-SO-28-09, DCD-SO-28-10, DCD-SO-28-10FD, DCD-SO-28-11, DCD-SO-28-12, DCD-SO-28-19, and DCD-SO-28-24). These surface soil samples were all located in the central portion of the landfill (Figure 5.1). Detected concentrations of benzo(a)pyrene range from 0.056J mg/kg (sample DCD-SO-28-19) to 0.15J mg/kg (sample DCD-SO-28-24). The maximum concentration of 0.15J mg/kg was detected at sample DCD-SO-28-24. Benzo(b)fluoranthene was detected above its respective residential soil RSL of 0.15 mg/kg in four surface soil samples and one associated field duplicate (DCD-SO-28-09, DCD-SO-28-10, DCD-SO-28-10FD, DCD-SO-28-11, and DCD-SO-28-24). As stated previously, these surface soil samples were all located in the central portion of the landfill (Figure 5.1). Detected concentrations of benzo(b)fluoranthene range from 0.053J mg/kg (sample DCD-SO-28-15) to 0.31J mg/kg (sample DCD-SO-28-24). The maximum concentration of 0.31J mg/kg was detected at sample DCD-SO-28-24 and was only slightly greater (2.1 times) than its respective soil RSL of 0.15 mg/kg. Exceedances of benzo(a)pyrene and benzo(b)fluoranthene in the surface samples were bounded laterally to the east by sample DCD-SO-28-08 and bounded laterally to the west by sample DCD-SO-28-25.

Even though benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, and dibenz(a,h)anthracene were detected above their corresponding USEPA (2013a) residential RSL, the frequency of detection was less than 30-percent for these four polycyclic aromatic hydrocarbon (PAHs). Additionally, there were no detections of these four PAHs in the subsurface soil samples collected from the landfill. PAHs are both naturally occurring and anthropogenic, and they are ubiquitous in the environment. Nearby sources of PAHs (e.g., wind-blown dust, burned grass, and asphalt used for roads and parking areas) represent the most likely

source for the detected PAHs in SWMU 28 surface soils. Therefore, the trace detections of PAHs are not considered to be attributable to the SWMU 28 landfill. As such, the nature and extent of chemicals detected in surface soil has been adequately characterized at SWMU 28 and additional surface soil sampling is not required.

5.2 SOIL GAS RESULTS

A total of seven collated VMPs were installed at 5 ft bgs and 12 ft bgs. After installation, the VMPs were sampled using certified clean 1-liter Summa® canisters and all samples were analyzed for VOCs. A summary of analytical results for VOCs detected in the soil gas samples is presented in Appendix D, Table D.2.

Fourteen active soil gas samples and two field duplicates were collected from the seven collocated VMPs at SWMU 28. At each VMP, soil gas samples were collected at depths of 5 ft bgs within the zone of buried waste and at approximately 12 ft bgs, from just below the buried waste. A total of 14 VOCs were detected in one or more of the soil gas samples. The analytes primarily detected include acetone, chloroform, dichlorodifluoromethane, ethylbenzene, m,p-xylene, o-xylene, toluene and trichlorofluoromethane. The VOCs 1,1,1-trichloroethane, 1,2,4-trimethylbenzene, 1,3,5-trimethylbenzene, carbon tetrachloride, PCE and TCE were also detected; however, the frequency of detection was less than 20-percent for these analytes. The maximum detected concentrations were primarily detected in the western portion of the site at sample SG-28-01 (Table 5.2). With the exception of acetone and 1,3,5-trimethylbenzene, all maximum soil gas concentrations of VOCs were detected in samples from the deeper interval (12 ft bgs). It is hypothesized that the higher concentration of VOCs in deeper intervals may be due to entrapment of VOC vapors beneath plastic sheeting. Large amounts of plastic sheeting were observed throughout the landfill during the October 2012 test pit operations (Inset 3), and collectively, this plastic sheeting may be acting as an unintentional vapor barrier in the soil. Soil gas analytes that exceed their



Inset 3 – The test pit operation found large amounts of plastic in the test pits excavated in the landfill.

TABLE 5.2
SUMMARY STATISTICS FOR SOIL GAS SAMPLES ($\mu\text{g}/\text{m}^3$)
RCRA Facility Investigation Addendum Report for SWMU 28
Tooele Army Depot - South Area

Chemical	N	#D	%D	Min LOD ¹	Max LOD ¹	MinD	MaxD	Sample Location of MaxD
1,1,1-Trichloroethane	16	3	19%	2.78	3.71	2.67	5.46	DCD-SG-28-01-12
1,2,4-Trimethylbenzene	16	3	19%	2.51	3.34	2.41	6.88	DCD-SG-28-01-12
1,3,5-Trimethylbenzene	16	1	6%	2.51	3.34	1.72	1.72	DCD-SG-28-01-05
Acetone	16	16	100%	-	-	61.8	618	DCD-SG-28-01-05
Carbon Tetrachloride	16	1	6%	3.21	4.28	7.55	7.55	DCD-SG-28-01-12
Chloroform	16	14	88%	2.59	2.78	2.39	684	DCD-SG-28-01-12
Dichlorodifluoromethane	16	16	100%	-	-	1.83	6.43	DCD-SG-28-06-12
Ethylbenzene	16	16	100%	-	-	1.26	7.38	DCD-SG-28-01-12
m,p-Xylene	16	16	100%	-	-	8.68	40.8	DCD-SG-28-01-12
o-Xylene	16	16	100%	-	-	2.17	10.4	DCD-SG-28-01-12
Tetrachloroethene	16	3	19%	3.46	4.61	11.5	19	DCD-SG-28-01-12
Toluene	16	16	100%	-	-	2.37	16.6	DCD-SG-28-01-12
Trichloroethene	16	1	6%	4.57	5.91	6.45	6.45	DCD-SG-28-02-12
Trichlorofluoromethane	16	16	100%	-	-	2.25	787	DCD-SG-28-01-12

Notes:

1 The maximum and minimum LODs are presented to show the detection limit range for each detected analyte.

Definitions:

"-" Data unavailable

N Total number of samples analyzed

#D Number of detects

%D Percentage of detects

Min LOD Minimum limit of detection

Max LOD Maximum limit of detection

MinD Minimum detected value

MaxD Maximum detected value

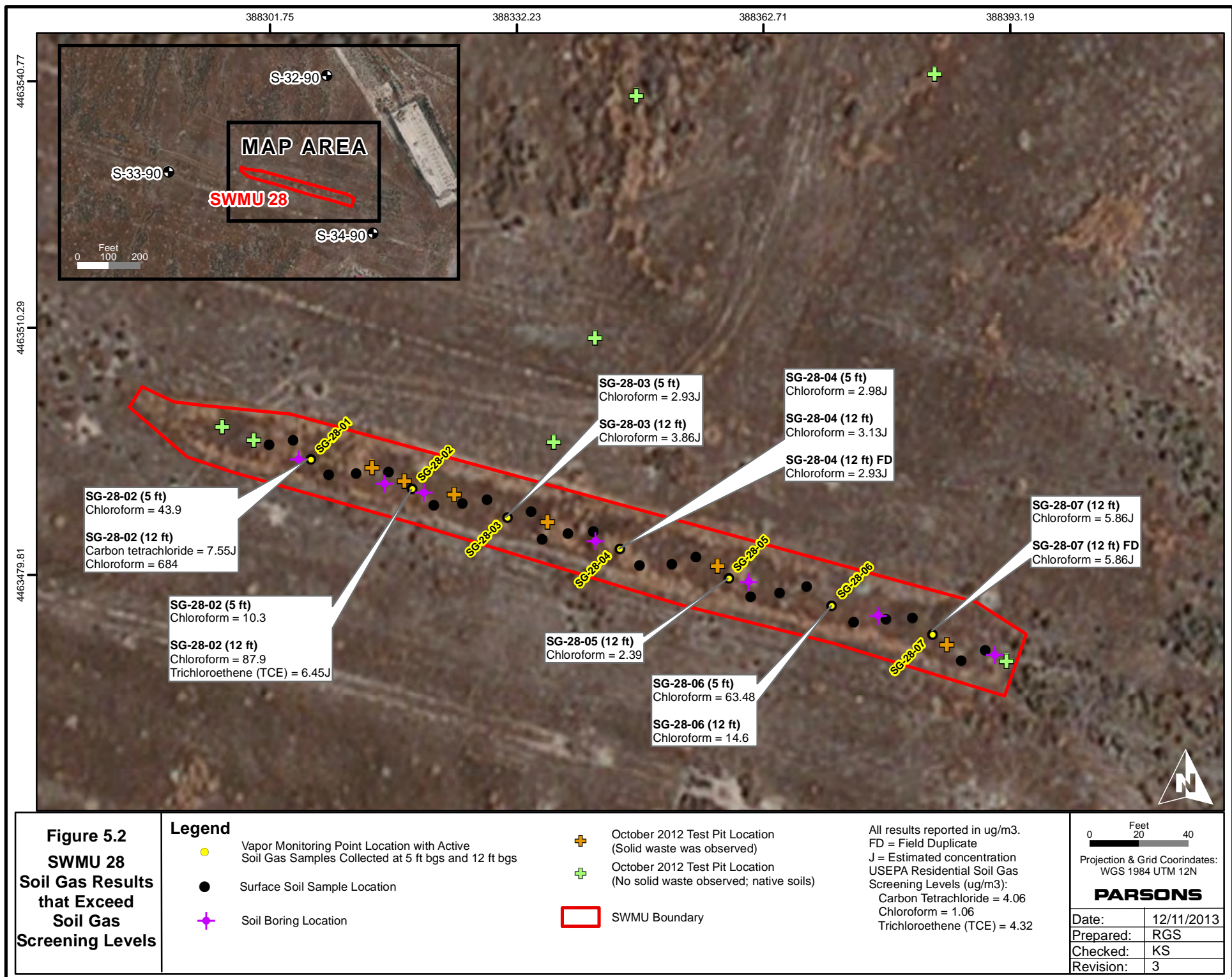
corresponding USEPA (2013b) residential vapor intrusion screening level are shown on Figure 5.2. A vapor intrusion screening assessment and an evaluation of potential human health risks from soil gas migrating into indoor air is presented in Section 6.0.

5.3 SUBSURFACE SOIL FIELD OBSERVATIONS AND RESULTS

Based on the deeper nature of the soil gas detections, further evaluation of subsurface soils was necessary to assess the nature and extent of contamination at SWMU 28. A total of 35 subsurface soil samples and four field duplicates were collected from seven soil borings at SWMU 28. Both soils and landfill debris were logged as each boring was advanced. In general, landfill debris was observed between 3.5 to 14 ft bgs. Dark black or rust stained soil was observed in this debris zone (Table 5.3).

TABLE 5.3
GENERAL OBSERVATIONS FROM SOIL BORINGS
RCRA Facility Investigation Addendum for SWMU 28
Tooele Army Depot - South Area

Soil Boring	Depth (ft bgs)	Observations
SB-28-01	13.5 - 14	Dark black stained soil, wood pieces; no odor.
	15 - 25	Native soils observed.
SB-28-02	4.5 - 5.0	Rust stained soil.
	10 - 14	Dark black stained soil, mixed with wood pieces and clear plastic sheeting; no odor.
	14 - 25	Native soils observed.
SB-28-03	0 - 25	No debris was observed in this soil boring.
SB-28-04	3.5 - 4.0	Rust stained layer.
	8 - 12.5	Soil intermixed with dark black staining, foam particles, pieces of wood, and plastic sheeting; no odor.
	12.5 - 25	Native soils observed.
SB-28-05	4 - 12	Soil intermixed with dark black staining, burnt wood, plastic sheeting, and rust staining; no odor.
	12 - 25	Native soils observed.
SB-28-06	9 - 13	Landfill debris including a tire remnant; no odor. At 12.5 - 13 ft bgs, a saturated, dark black stained area was observed; no odor.
	13 - 25	Native soils observed.
SB-28-07	10 - 10.2	Rust stained soil and wood fragments; no odor.
	10.2 - 25	Native soils observed.



Buried debris observed in the soils cores included plastic sheeting, pieces of wood, and rubber tire remnants. No anomalous odors were noted and no elevated PID readings were detected; all drill cuttings registered a PID reading of 0.0 ppm. The PID readings taken from subsurface soil cores are recorded in the field logbook and in the boring logs (Appendix A). Native soils were encountered below the landfill debris zone, at approximately 12 to 15 ft bgs. Table 5.3 summarizes key observations from the boring logs (Appendix A). Photographs of the drill cuttings are presented in Appendix B.

Subsurface soil samples collected at SWMU 28 had detections of select VOCs, SVOCs, and metals (Table 5.4). A summary of the soil analytical results from these samples is presented in Appendix D. Chloroform was the only VOC detected. A total of 12 SVOCs (2,4-dimethylphenol, 2-methylphenol, 3/4-methylphenol, benzo(g,h,i)perylene, bis(2-ethylhexyl)phthalate, carbazole, chrysene, dimethylphthalate, fluoranthene, phenanthrene, phenol, and pyrene) were detected at low levels in one or more of the subsurface soil samples (Table 5.4). The frequency of detection was less than 10-percent for all detected SVOCs analytes. Metals were also detected in all subsurface soil samples.

The background comparison evaluation, USEPA (2013a) residential soil RSL comparison, and professional judgment steps described previously for surface soils are presented below for the subsurface soil sample results.

Step 1 – Background Threshold Value Comparison

Twenty-one metals (aluminum, antimony, arsenic, barium, beryllium, cadmium, calcium, chromium, cobalt, copper, iron, lead, magnesium, manganese, mercury, nickel, selenium, silver, sodium, vanadium and zinc) detected in subsurface soils had maximum site concentrations greater than their corresponding background comparison values. A comparison to TEAD-S background values is shown in Table 5.4. Although calcium, magnesium, and sodium exceeded their respective background reference value, these analytes are classified as essential nutrients (USEPA 1989) and therefore, are not further evaluated.

Aluminum, barium, beryllium, cadmium, chromium, cobalt, copper, iron, lead, manganese, vanadium, and zinc concentrations were determined to be similar to background concentrations in the subsurface soil site-attribution analysis presented in Appendix F. Based on this analysis, no further characterization is required for these analytes.

TABLE 5.4
SUMMARY STATISTICS FOR DETECTED RESULTS IN SUBSURFACE SOIL SAMPLES (>0.5 FT BGS) (mg/kg)
RCRA Facility Investigation Addendum Report for SWMU 28
Tooele Army Depot - South Area

Chemical	N	#D	%D	Min LOD ¹	Max LOD ¹	Min D	Max D	Background Reference Value ³	Exceeds Background?	Residential Soil RSL ⁴	Exceeds RSL?	Location of Max Detect
Inorganics												
Aluminum	39	39	100%	-. ²	-	2,100	24,000	17,610	Yes ⁵	77,000	No	DCD-SB-28-01-05
Antimony	39	1	3%	4.2	5.6	3.40	3.4	0.96	Yes	31	No	DCD-SB-28-04-25
Arsenic	39	39	100%	-	-	4.7	110	35	Yes ⁶	0.61	NE	DCD-SB-28-01-15
Barium	39	39	100%	-	-	20	290	239.8	Yes ⁵	15,000	No	DCD-SB-28-01-05
Beryllium	39	24	62%	0.68	0.83	0.26	38	0.97	Yes ⁵	160	No	DCD-SB-28-01-10
Cadmium	39	38	97%	0.45	0.45	0.3	1.5	1.2	Yes ⁵	70	No	DCD-SB-28-05-05
Calcium	39	39	100%	-	-	53,000	350,000	121,000	Yes ⁷	ES	ES	DCD-SB-28-07-20
Chromium	39	39	100%	-	-	9.1	38	19.8	Yes ⁵	120000 ⁸	No	DCD-SB-28-06-05FD
Cobalt	39	39	100%	-	-	1.5	11	5.7	Yes ⁵	23	No	DCD-SB-28-01-05 DCD-SB-28-05-05
Copper	39	39	100%	-	-	5.1	67	32.4	Yes ⁵	3100	No	DCD-SB-28-05-10
Iron	39	39	100%	-	-	5,400	86,000	15,460	Yes ⁵	55,000	NE	DCD-SB-28-05-10
Lead	39	39	100%	-	-	4.4	150	39.3	Yes ⁵	400	No	DCD-SB-28-06-05FD
Magnesium	39	39	100%	-	-	7,900	71,000	17,240	Yes ⁷	ES	ES	DCD-SB-28-01-15
Manganese	39	39	100%	-	-	160	1200	698.7	Yes ⁵	1800	No	DCD-SB-28-05-05
Mercury	39	38	97%	0.029	0.029	0.017	0.11	0.05	Yes	10	No	DCD-SB-28-07-20FD DCD-SB-28-05-05 DCD-SB-28-02-10
Nickel	39	39	100%	-	-	6.4	43	14.5	Yes	1500	No	DCD-SB-28-06-05
Potassium	39	39	100%	-	-	360	7,400	9,131	No	ES	ES	DCD-SB-28-05-05
Selenium	39	11	28%	4.2	5.6	1.6	4.5	1.4	Yes	390	No	DCD-SB-28-04-15
Silver	39	21	54%	0.63	0.84	0.23	0.89	NA	NA	390	No	DCD-SB-28-05-05
Sodium	39	38	97%	190	190	120	5200	581.4	Yes ⁷	ES	ES	DCD-SB-28-01-05
Vanadium	39	39	100%	-	-	7.9	45	27.94	Yes ⁵	390	No	DCD-SB-28-01-05
Zinc	39	39	100%	-	-	13	980	77.1	Yes ⁵	23,000	No	DCD-SB-28-04-15
Volatile Organic Compounds												
Chloroform	39	3	8%	0.0008	0.0012	0.0006	0.0027	NA	NA	0.29	No	DCD-SB-28-02-10

TABLE 5.4
SUMMARY STATISTICS FOR DETECTED RESULTS IN SUBSURFACE SOIL SAMPLES (>0.5 FT BGS) (mg/kg)
RCRA Facility Investigation Addendum Report for SWMU 28
Tooele Army Depot - South Area

Chemical	N	#D	%D	Min LOD ¹	Max LOD ¹	Min D	Max D	Background Reference Value ³	Exceeds Background?	Residential Soil RSL ⁴	Exceeds RSL?	Location of Max Detect
Semi-Volatile Organic Compounds												
2,4-Dimethylphenol	39	1	3%	0.1	0.45	0.069	0.069	NA	NA	1200	No	DCD-SB-28-06-10
2-Methylphenol	39	1	3%	0.1	0.45	0.068	0.068	NA	NA	3100	No	DCD-SB-28-06-10
3/4-Methylphenol	39	1	3%	0.1	0.45	0.1	0.1	NA	NA	6100	No	DCD-SB-28-06-10
Benzo(g,h,i)perylene	39	1	3%	0.1	0.12	0.19	0.19	NA	NA	1700 ⁹	No	DCD-SB-28-02-15
bis(2-Ethylhexyl)phthalate	39	4	10%	0.1	0.12	0.24	2.2	NA	NA	35	No	DCD-SB-28-06-05
Carbazole	39	1	3%	0.1	0.12	0.21	0.21	NA	NA	NA	NA	DCD-SB-28-02-15
Chrysene	39	2	5%	0.1	0.12	0.052	1.7	NA	NA	15	No	DCD-SB-28-02-15
Dimethylphthalate	39	2	5%	0.1	0.45	0.041	0.046	NA	NA	NA	NA	DCD-SB-28-01-05
Fluoranthene	39	1	3%	0.1	0.12	0.39	0.39	NA	NA	2300	No	DCD-SB-28-02-15
Phenanthrene	39	1	3%	0.1	0.12	0.72	0.72	NA	NA	3.6 ¹⁰	No	DCD-SB-28-02-15
Phenol	39	1	3%	0.1	0.45	0.073	0.073	NA	NA	18000	No	DCD-SB-28-06-10
Pyrene	39	1	3%	0.1	0.12	0.76	0.76	NA	NA	1700	No	DCD-SB-28-02-15

Notes:

- 1 The maximum and minimum LODs are presented to show the detection limit range for each detected analyte.
- 2 LOD not reported because chemical was detected in 100-percent of the samples.
- 3 AQS (2013). Final Risk Assumptions Document Solid Waste Management Units and Other Corrective Action Sites. Deseret Chemical Depot, Tooele, Utah. Revision 2. January.
- 4 USEPA (2013a). Residential Soil Regional Screening Level. May. <http://www.epa.gov/region9/superfund/prg/>.
- 5 Even though maximum detected concentration exceeds background reference value, site attribution found these analytes to be similar to background (Appendix F).
- 6 Even though maximum detected concentration exceeds background reference value, based on professional judgement arsenic is similar to background.
- 7 Even though maximum detected concentration exceeds background reference value, these analytes are essential nutrients.
- 8 No RSL available. Trivalent chromium used a surrogate.
- 9 No RSL available. Pyrene used a surrogate.
- 10 No RSL available. Naphthalene used a surrogate.

Definitions:

ES Essential nutrient	%D Percentage of detects
N Total number of samples analyzed	Min LOD Minimum limit of detection
NA Not available	Max LOD Maximum limit of detection
NE Not evaluated	Min D Minimum detected value
#D Number of detects	Max D Maximum detected value

The two-sample hypothesis test determined site concentrations of nickel differ from background concentrations, and therefore, nickel was retained for further analysis. Due to insufficient number of detections in the background data set, the site-attribution evaluation was not conducted for antimony, selenium and mercury; therefore, these analytes were retained for further analysis. No background value (or background data set) is available for silver; therefore, silver was carried forward to the subsequent steps in this analysis.

Detected concentrations of arsenic ranged from 4.7 to 110 mg/kg. The maximum detected concentration (110 mg/kg) came from a depth of 15 ft bgs in sample DCD-SB-28-01-15, located in the western end of the landfill. Only three out of 39 subsurface soil samples had concentrations of arsenic that exceeded the background reference value of 35 mg/kg (DCD-SB-28-01-15, DCD-SB-28-05-10, and DCD-SB-28-04-10). Although the arsenic concentration in three soil samples were greater than the background reference value (35 mg/kg), arsenic concentrations from samples collected at the landfill are concluded to be representative of site background conditions based on the following lines of evidence:

- Natural arsenic concentrations vary significantly across TEAD-S with previously recorded levels as high as 52 mg/kg in soil, and with a maximum concentrations commonly reported in the 35-38 mg/kg range (AQS, 2013).
- The Oquirrh Mountains, immediately west of TEAD-S, are a known source of arsenic and are one of the most mineralized mountain ranges in Utah. It is reasonable to conclude that much of the subsurface soil and gravel at TEAD-S is derived in some manner from these mountains.
- The arsenic detection at sample DCD-SB-28-01-15 of 110 mg/kg was bound vertically by deeper samples collected at 20 and 25 ft bgs; these deeper samples had arsenic concentrations of 15 mg/kg and 12 mg/kg, respectively. Additionally, sample DCD-SB-28-01-15 was bound vertically by shallower samples collected at 5 and 10 ft bgs with detected concentrations of 22 mg/kg and 17 mg/kg, respectively. Therefore, the detection of 110 mg/kg in soil boring DCD-SB-28-01-15 represents an isolated occurrence. Due to the relatively small sample size used for the metals analysis in the lab (0.5 grams), it is believed that this elevated arsenic detection at sample DCD-SB-28-01-15 demonstrated a variable concentration commonly referred to as the “nugget” effect.
- The arsenic detection at sample DCD-SB-28-05-10 of 45 mg/kg is only slightly greater than the background concentration of 35 mg/kg (AQS, 2013). Additionally, this arsenic detection was bound vertically by deeper samples collected at 15, 20 and

25 ft bgs, with detected arsenic concentrations of 19 mg/kg, 9.2 mg/kg, and 8.9 mg/kg, respectively.

- Similarly, the arsenic detection at sample DCD-SB-28-04-10 of 37 mg/kg is only slightly greater than the background concentration of 35 mg/kg (AQS, 2013), and it too was bound vertically by deeper samples collected at 15, 20 and 25 ft bgs, with detected concentrations of 12 mg/kg, 8 mg/kg, and 9.8 mg/kg, respectively.

Based on the evaluation presented in Appendix F and summarized above, arsenic concentrations in the subsurface soils at SWMU 28 are not site-related, and are therefore concluded to be naturally occurring. Therefore, antimony, mercury, nickel, selenium, and silver were the only metals further evaluated in subsequent steps in this analysis.

Step 2 – Residential Soil RSL Comparison

Maximum soil concentrations of organic compounds and metals carried forward from Step 1 were conservatively compared with their corresponding USEPA (2013a) residential soil RSLs as one step in determining whether additional characterization of subsurface soils is required. The comparison to residential soil RSLs is presented in Table 5.4. The evaluation showed that although several organic compounds were detected in site soils, no organic compound had concentrations above its corresponding USEPA (2013a) residential RSL. Additionally, the maximum detected concentration of antimony, mercury, nickel, selenium, and silver were below the corresponding residential RSLs (Table 5.4). The nature and extent of chemicals detected in subsurface soils at SWMU 28 has been adequately characterized, and additional subsurface soil sampling is not required.

5.4 IDW RESULTS

5.4.1 Decontamination/Rinse Water

A composite sample was collected from each decontamination water IDW drum and analyzed for total VOCs and SVOCs. These analytical results of the decontamination water were screened against the USEPA maximum contaminant level (MCL) to determine if the IDW water constitutes hazardous or non-hazardous waste. A summary of analytical results is presented in Appendix E, Table E.2. Sample DCD-IDW-WA-19/27-01 was collected from IDW drum PGS1307102 which was used during the initial phase of the investigation. A total of 28 analytes were detected (22 VOCs and six SVOCs) in sample DCD-IDW-WA-19/27-01. Bis(2-

ethylhexyl)phthalate had a detected concentration of 7.1 µg/L exceeding its corresponding MCL of 6 µg/L. All other detected analytes were below their respective MCL. Due to the exceedance of bis(2-ethylhexyl)phthalate, decontamination water within drum PGS1307102 was determined to be hazardous waste and was transported off-site and disposed of at the Clean Harbors Aragonite Facility.

IDW Sample IDW-WA-28-01 was collected from drum PGS1328802. A total of seven analytes were detected (one VOCs and six SVOCs) in sample IDW-WA-28-01 (i.e., acetone, bis(2-ethylhexyl)phthalate, 2,4-dimethylphenol, butylbenzylphthalate, diethylphthalate, di-n-butyl phthalate, di-n-octyl phthalate). Bis(2-ethylhexyl)phthalate was detected at a concentration of 13 µg/L and exceeded its corresponding MCL value of 6 µg/L. The remaining six detected analytes do not have MCLs. Due to the exceedance of bis(2-ethylhexyl)phthalate, decontamination water within drum PGS1328802 was determined to be hazardous waste and was transported off-site and disposed of at the Clean Harbors Aragonite Facility.

5.4.2 Soil Cuttings

A soil sample was collected from each soil IDW drum and analyzed for TCLP VOCs and TCLP RCRA metals. A summary of analytical results is presented in Appendix E, Table E.3. Sample DCD-IDW-SO-19-01 was collected from IDW drum PGS1307101 which was used during the initial phase of the investigation. Drum PGS1307101 also included drill cuttings and associated drill slough from concurrent field activities conducted at SWMU 19. Per discussions between TEAD-S and UDEQ, it was agreed that drums that contained soil cuttings from 0 - 30 ft bgs from borehole S-123-13 at SWMU 19 should be treated as hazardous waste due to the presences of low level VOC detections in the environmental samples. Therefore, drum PGS1307101 was determined to be hazardous waste and was transported off site and disposed of by Clean Harbors at Grassy Mountain Landfill.

Sample DCD-IDW-SO-28-01 was collected from IDW drum PGS1328801. Three TCLP RCRA metals were detected (barium, cadmium, and lead); however, all detected results were below RCRA regulatory TCLP limits. No VOCs were detected. Since no constituents were detected above TCLP limits, IDW drum PGS1328801 was determined to be non-hazardous and soil cuttings were returned to the SWMU 28 site and spread across the ground.

SECTION 6.0

HUMAN HEALTH AND ECOLOGICAL RISK ASSESSMENT

The human health and ecological risk assessment evaluates the potential for human health and ecological impacts from exposure to chemicals of potential concern (COPCs) at SWMU 28. Detailed analysis methods and exposure assumptions used to assess potential human health and ecological risks/hazards associated with exposure to contaminants are described in the TEAD-S Risk Assumptions Document (RAD; AQS, 2013), and are consistent with UAC R315-101: Cleanup Action and Risk-Based Closure Standards (DSHW, 2011).

6.1 HUMAN HEALTH RISK ASSESSMENT

Per the TEAD-S RAD (AQS, 2013), a risk assessment was conducted using residential and industrial (actual) land use exposure scenarios to determine potential risks and hazards to receptors from exposure to contaminants at SWMU 28. The results of this human health risk assessment (HRA) will provide a basis for decisions regarding further action, if necessary, with respect to the COPCs at the site. This risk assessment is consistent with TEAD-S (AQS, 2013) guidance and consists of the following four steps:

- Identifying potentially complete exposure pathways based on the conceptual site model (CSM)
- Identifying COPCs
- Estimating exposure point concentrations
- Estimating potential health risks

Each of these steps is explained in detail below.

6.1.1 Development of the Conceptual Site Model

Developing a CSM is a critical step in properly evaluating potential exposures at a site. The CSM is a comprehensive representation of the site that documents the potential for exposure (under current and future land use) to chemicals at a site based on the source(s) of contamination, the release mechanism(s), migration route(s), exposure pathway(s), and receptor(s) either at the site or that may reasonably be anticipated to be at the site (AQS, 2013).

6.1.2 Investigation Area

1 This risk assessment focuses on SWMU 28 located in the northeastern portion of the
2 TEAD-S installation, approximately 1,000 feet southwest of the TEAD-S Administration Area.
3 SWMU 28 is an inactive (abandoned) landfill encompassing approximately 0.3 acres.

6.1.3 Sources, Release Mechanisms, and Affected Media

4 The source material for the landfill cover was not documented at the time the landfill
5 cover was installed. Similarly, the potential for contaminant releases from buried debris in the
6 landfill has not been evaluated. The primary release mechanism for chemicals at the site is likely
7 from the landfill cover or buried debris. The landfill debris is largely municipal, construction,
8 and household wastes. Reportedly, no noxious or hazardous materials were disposed of at this
9 site, and the landfill was filled to grade and revegetated in 1972.

6.1.4 Identification of Human Receptors

10 The primary mission for TEAD-S of storing and demilitarizing chemical munitions has
11 been completed. As such, facilities at the installation related to demilitarization are currently
12 being closed. The entire 19,364 acres was transferred to TEAD in July 2013. Access to TEAD-
13 S is restricted and only approved personnel can enter the military installation.

14 At present, SWMU 28 is an inactive (abandoned) landfill. Like all SWMUs at TEAD-S,
15 SWMU 28 is classified as an industrial land-use site and will remain so for the foreseeable
16 future. Thus, under current conditions, the human receptors that are most likely to be exposed to
17 any chemicals potentially present at the site are industrial or construction workers. Residential
18 use of SWMU 28 is not likely in the near future. However, hypothetical residential land use for
19 SWMU 28 is assumed here for informational purposes in order to determine: 1) whether land
20 use restrictions are needed; and 2) the feasibility of achieving clean closure (i.e., no further
21 action) under an unrestricted land use scenario. It is unlikely that trespassers would visit the
22 SWMU 28 site, given the security infrastructure present at the TEAD-S installation. However, if
23 trespassers did access the site, their exposures (and subsequent risks) would be less than that of
24 either a resident or an industrial worker. Therefore, trespassers were not selected for evaluation.
25 In summary, three human receptor groups were selected for evaluation at the site: 1)
26 hypothetical residents, 2), industrial workers, and 3) construction workers.

6.1.5 Exposure Pathway Analysis

USEPA (1989) defines an exposure pathway as “*the course a chemical or physical agent takes from a source to an exposed organism. An exposure pathway describes a unique mechanism by which an individual or population is exposed to chemicals or physical agents at or originating from a site. Each exposure pathway includes a source or release from a source, an exposure point, and an exposure route. If the exposure point differs from the source, a transport/exposure medium (e.g., air) or media (in cases of intermedia transfer) also is included.*” A review of the potential exposure pathways associated with the potentially affected media at the site is presented in the following sections.

6.1.5.1 Soil Exposure Pathways

Soil represents a transport medium for, and a secondary source of, site-related chemicals. Potential release mechanisms for site-related chemicals in soil include tracking, excavation (animal or human), fugitive dust, incidental ingestion, and dermal contact. Many factors affect the release and bioavailability of soil COPCs. Soil geochemistry, including temperature, pH, organic content, particle size, and moisture content, solubility, and adsorption/desorption rates, are examples of such factors. Industrial workers are assumed to be exposed only to surface soils (i.e., 0 to 0.5 ft bgs). However, it is assumed that residents may plant trees, install pools, dig basements, etc. and are, therefore, assumed to be exposed to soils up to 10 ft bgs. Potential construction activities at the site may require excavations up to 10 ft bgs. Therefore, construction workers are assumed here to be exposed to soils up to 10 ft bgs.

The primary release mechanism for chemicals at the site is likely related to debris found on the surface and in the subsurface of the landfill. As a result, surface and subsurface soils were assumed to be complete exposure pathways at SWMU 28.

6.1.5.2 Air Exposure Pathways

USEPA (2004) defines VOCs as chemicals with a Henry's Law constant of 1×10^{-5} atm-m³/mole or greater and with a molecular weight of less than 200 g/mole. Chemicals meeting these criteria are assumed to be able to volatilize from soils and be emitted to the atmosphere and/or indoor air. As several chemicals classified as VOCs were detected in soils at the site, residential and industrial receptors were assumed to be exposed to volatiles emitted from soils to indoor air. However, construction workers spend their time outdoors and are engaged in outdoor

1 construction, digging or excavation activities. Therefore, potential exposures from VOCs that
2 have migrated to indoor air were assumed to be an incomplete exposure pathway for construction
3 workers and were not evaluated.

4 Wind erosion of soil particulates and heavy equipment use during construction could
5 potentially result in the aerial suspension of the nonvolatile chemicals detected in soils at the site
6 as dust. Therefore, it was assumed that residents, industrial workers, and construction workers at
7 the site could potentially be exposed to chemicals in soils by the inhalation of airborne dusts.

6.1.5.3 Surface Water Exposure Pathways

8 No perennial surface water bodies were identified at SWMU 28. Therefore, potential
9 exposures to surface water were assumed to be incomplete and are not evaluated here.

6.1.5.4 Groundwater Exposure Pathways

10 Groundwater is anticipated to occur at approximately 200 ft bgs at the site and does not
11 discharge to the surface. Therefore, residents and construction workers will not come into
12 contact with groundwater during excavations. Groundwater quality at SWMU 28 has been
13 categorized as Class II – Drinking Water Quality Ground Water. However, at present,
14 groundwater is not used as a source of potable water at the site.

15 Three groundwater monitoring wells were installed near SWMU 28 in 1990 (S-32-90, S-
16 33-90 and S-34-90). As discussed in Section 2.3.4, historical groundwater results show that low
17 concentrations of SVOCs have been sporadically detected in each of the three groundwater
18 wells. With the exception for bis(2-ethylhexyl)phthalate, none of the detections exceeded their
19 corresponding MCL (USEPA, 2009). One isolated bis(2-ethylhexyl)phthalate detection was
20 reported above the MCL in well S-33-90 during sampling performed in 1995. This analyte was
21 not detected above the MCL in any SWMU 28 wells during subsequent sampling events. No
22 explosive detections were reported in the numerous groundwater samples collected from these
23 wells (Parsons, 2013c). Evaluation of the soil-to-groundwater migration pathway is discussed
24 below.

6.1.5.5 Exposure Pathway Summary

25 For the purpose of this evaluation, it was assumed that residents and industrial workers at
26 the site could potentially be exposed to chemicals by dermal contact with soil, incidental soil
27 ingestion, the inhalation of airborne dusts, and the inhalation of volatiles emitted from soils to

the atmosphere and indoor air. Also, it was assumed that construction workers could potentially be exposed to chemicals by dermal contact with soil, incidental soil ingestion, and the inhalation of airborne dusts. These potentially complete exposure pathways are shown in the CSM (Figure 6.1).

6.1.6 Evaluation of Potential Groundwater Impacts

Compliance with UAC R315-101-3 (the Principle of Non-Degradation) was determined by evaluating the potential for chemicals detected in soils to impact groundwater in the future via the soil-to-groundwater pathway. The potential for future impacts to groundwater underlying SWMU 28 was evaluated by using a tiered approach as specified in the TEAD-S Risk Assumptions Document (AQS, 2013). For the first step of the tiered approach (Tier 1), maximum soil concentrations of potentially site-related analytes were compared with generic soil-to-groundwater soil screening levels (SSLs) based on a default dilution attenuation factor (DAF) of 20. The following analytes were detected at concentrations that exceeded their respective generic soil-to-groundwater SSLs (Table 6.2): benzo(a)pyrene, chloroform, cobalt, iron, and thallium. The potential soil-to-groundwater impacts from these four analytes were evaluated further.

For the Tier 2 evaluation, site-specific soil-to-groundwater SSLs and DAFs were calculated based on fate and transport modeling following USEPA (1996a, b) guidance. The 95-percent upper confidence limit (UCL) was used as the exposure point concentration (EPC) for benzo(a)pyrene, cobalt, iron, and thallium. However, chloroform data sets did not meet the USEPA (2013c) minimum requirements for calculating a 95-percent UCL (i.e., at least eight samples and a minimum of five detections). Therefore, the average concentration was used as the EPC for chloroform. As stated in USEPA (1996a), the calculation of soil-to-groundwater SSLs is most sensitive to the DAF. Site-specific inputs were used to calculate the DAF. The site-specific hydraulic gradient (0.002) and hydraulic conductivity (3.16×10^4 m/yr) were based on the data collected from the three existing groundwater monitoring wells at SWMU 28 (S-32-90, S-33-90, and S-34-90). The site-specific DAF for this site was 119.18 (Appendix G, Attachments G.1.1 and G.1.2).

Based on the Tier 2 screening, using the site-specific DAF of 119.8, no analytes exceeded their respective site-specific SSLs (Table 6.2). Therefore, based on the results from the soil-to-groundwater evaluation, the compounds detected in soils at SWMU 28 are not present at

1 concentrations that will significantly impact groundwater in the future and degradation of natural
2 resources is not likely.

6.2 CHEMICALS OF POTENTIAL CONCERN (COPCS)

3 Chemicals of potential concern are those chemicals detected in environmental media at
4 the site for which human contact may result in adverse health effects. The selection of COPCs
5 consists of a two step process, as follows:

- 6 • Data review – evaluation of data collected at the site to determine its suitability for
7 risk assessment
- 8 • Selection of COPCs – evaluates the suitable data to determine which chemicals
9 should be evaluated in the risk assessment

10 Each of the two steps is presented below.

6.2.1 Data Review

11 Parsons collected soil and soil gas samples at SWMU 28 in March and October of 2013.
12 The soil and soil gas sample results are presented in Appendix D. All data collected by Parsons
13 were validated (see Appendix C), and all of the validated data were evaluated in the selection of
14 COPCs. Data validation classified the data through the use of several qualifiers. Data without
15 qualifiers were considered appropriate for risk assessment purposes; i.e., these data met the
16 criteria prescribed in the applicable QAPjP (Parsons, 2013a). Following USEPA guidance
17 (1989, 1992a), data with J qualifiers were used for risk assessment purposes. The J qualifier
18 indicates that the chemical identity is certain, but the concentration is estimated. Because of a
19 high degree of certainty in the identity of the chemical, all results flagged with a J qualifier will
20 be included in the quantitative risk assessment. However, inclusion of estimated concentrations
21 adds uncertainty to the risk assessment results. Data qualified U and UJ were considered to be
22 below laboratory detection limits (non-detect) but usable for risk assessment purposes.
23 However, inclusion of non-detect results adds uncertainty to the risk assessment results. Data
24 qualified R were excluded from this risk assessment (USEPA 1989, 1992a). The associated level
25 of uncertainty was acceptable because the data quality assessment conducted in Section 4.0
26 found the data to be suitable for decision-making purposes, including use in the human and
27 ecological risk assessment.

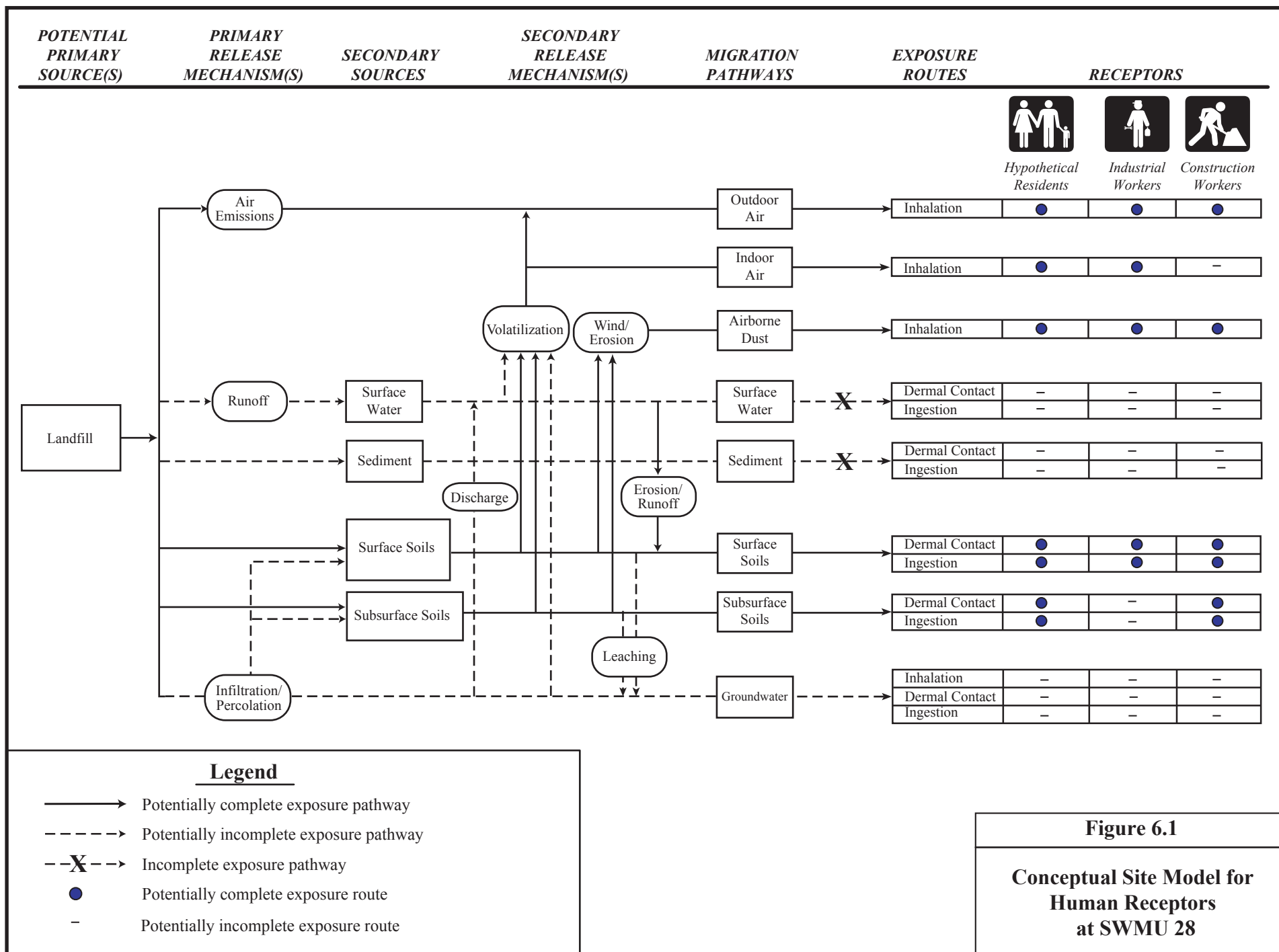


TABLE 6.1
SOIL GAS COMPARISON ¹
 RCRA Facility Investigation Addendum Report for SWMU 28
 Tooele Army Depot - South Area

Chemical	MaxD ($\mu\text{g}/\text{m}^3$)	USEPA (2013b) Residential Vapor Intrusion Screening Level ² ($\mu\text{g}/\text{m}^3$)	Exceeds?
1,1,1-Trichloroethane	5.46	52,143	No
1,2,4-Trimethylbenzene	6.88	73	No
1,3,5-Trimethylbenzene	1.72	NA	NA
Acetone	618	320,000	No
Carbon Tetrachloride	7.55	4.06	Yes
Chloroform	684	1.06	Yes
Dichlorodifluoromethane	6.43	1,000	No
Ethylbenzene	7.38	9.7	No
m,p-Xylene	40.8	1,000 ³	No
o-Xylene	10.4	1,000	No
Tetrachloroethene	19	93.6	No
Toluene	16.6	52,000	No
Trichloroethene	6.45	4.32	Yes
Trichlorofluoromethane	787	7,300	No

Notes:

- ¹ If two or more values are available for a given sample (i.e., field duplicate), the average of the values were used.
- ² USEPA (2013b) residential vapor intrusion screening level for target sub-slab and exterior soil gas concentrations.
- ³ No toxicity data available. m-Xylene used as a surrogate.

Definitions:

NA Not available
 $\mu\text{g}/\text{m}^3$ Micrograms per cubic meter
 MaxD Maximum detected value

TABLE 6.2
SCREENING FOR POTENTIAL SOIL-TO-GROUNDWATER IMPACTS
 RCRA Facility Investigation Addendum Report for SWMU 28
 Tooele Army Depot - South Area

Compound	Max Detect ¹ (mg/kg)	Generic Soil-to-GW SSLs ² (mg/kg)	Exceeds SSL Screening?	95% UCL (mg/kg)		Tier 2 Site-Specific SSL	Exceeds Tier 2
2,4-Dimethylphenol	0.069	6.4	no	-		-	-
2-Methylphenol	0.068	11.6	no	-		-	-
3-Methylphenol + 4-Methylphenol	0.100	22	no	-		-	-
Antimony	3.400	5.4	no	-		-	-
Benzo(a)anthracene	0.170	0.2	no	-		-	-
Benzo(a)pyrene	0.150	0.07	yes	0.0742		2.12	no
Benzo(b)fluoranthene	0.310	0.7	no	-		-	-
Benzo(g,h,i)perylene	0.190	NA	no	-		-	-
Benzo(k)fluoranthene	0.120	7	no	-		-	-
bis(2-Ethylhexyl)phthalate	1.285	22	no	-		-	-
Chloroform	0.003	0.00106	yes	0.001	3	0.01	no
Chrysene	1.700	22	no	-		-	-
Cobalt	11.000	4.2	yes	6.567		25.37	no
Dibenz(a,h)anthracene	0.051	0.22	no	-		-	-
Dimethylphthalate	0.220	NA	no	-		-	-
Fluoranthene	0.390	1400	no	-		-	-
Indeno(1,2,3-cd)pyrene	0.120	4	no	-		-	-
Iron	86000	5400	yes	17,908		59,369	no
Mercury	0.110	0.66	no	-		-	-
Nickel	37.000	400	no	-		-	-
Phenanthrene	0.720	NA	no	-		-	-
Phenol	0.073	52	no	-		-	-
Pyrene	0.760	190	no	-		-	-
Selenium	4.550	8	no	-		-	-
Silver	0.890	12	no	-		-	-
Thallium	0.53	0.22	yes	0.393		1.36	no
Zinc	650.00	5800	no	-		-	-

Notes:

- 1 Used maximum detected concentration from surface and subsurface soil data (0-25 ft bgs).
- 2 Risk-based SSLs (USEPA, 2013) based on a dilution attenuation factor of 20.
- 3 Due to the low frequency of detections for chloroform, the average concentration was used instead of a 95% UCL

Definitions:

"-" Soil-to-groundwater SSL not available
 ft bg feet below ground surface
 GW Groundwater
 mg/kg Milligrams per kilogram
 SSL Soil screening level

6.2.2 Selection of COPCs

The risk assessment site-attribution analysis for chemicals detected in soil is provided as Appendix F. The following inorganic analytes are surface (0-0.5 ft bgs) soil COPCs: antimony, cobalt, mercury, nickel, selenium, silver, and thallium. The following inorganic analytes are mixed (0-10 ft bgs) soil COPCs: antimony, cobalt, iron, mercury, nickel, selenium, silver, thallium, and zinc. All organics that were detected in soils were assumed to be the potential result of site activities and were retained as COPCs.

All organic analytes detected (i.e., not U qualified or UJ qualified) at least once were selected as COPCs and evaluated in this risk assessment. Chemicals that were 100-percent non-detect (ND) were eliminated from further quantitative consideration. Non-detect chemicals in soils with LOD that were greater than USEPA (2013a) residential soil RSLs (i.e., project action limits) are discussed in Section 4.0. Because these elevated detection limits are likely not to negatively affect the nature and extent evaluation or the risk assessment for soil, they present only a limited, and thus acceptable level of, uncertainty. Based on this review, usability of the data was not impacted and the non-detect results with elevated LODs did not affect the conclusions of the risk assessment.

6.2.3 Vapor Intrusion Screening Assessment

Residential and industrial receptors could be exposed to VOCs that have volatilized from soil through pore space in the vadose zone and building foundations into indoor air. An initial screening evaluation of the vapor intrusion pathway was conducted by comparing maximum detected soil gas concentrations to the USEPA (2013b) residential vapor intrusion (VI) screening levels (Table 6.1). The screening levels were calculated by dividing target indoor concentrations by a conservative attenuation factor of 0.1. The attenuation factor is the ratio of the indoor air concentration measured in a building to the vapor concentration measured in the subsurface materials underlying or adjacent to the building. The VI screening levels are based on default exposure parameters that represent reasonable maximum exposure conditions for chronic exposures and incorporate toxicity values from the November 2013 RSL tables.

The maximum detected soil gas concentration for three analytes exceeded their respective residential VI screening levels (carbon tetrachloride, chloroform, and trichloroethylene [TCE]). The VI screening level comparison is presented in Table 6.1. Chloroform was found to exceed its corresponding USEPA (2013b) residential VI screening level of 1.06 micrograms per cubic

meter ($\mu\text{g}/\text{m}^3$) at 12 soil gas locations (and two associated field duplicates). The maximum detected concentration of chloroform ($684 \mu\text{g}/\text{m}^3$) was detected in sample DCD-SG-01-12. Carbon tetrachloride was found to exceed its corresponding USEPA (2013b) residential VI screening level of $4.06 \mu\text{g}/\text{m}^3$ at one soil gas location (DCD-SG-01-12). TCE was found to exceed its corresponding USEPA (2013b) residential VI screening level of $4.23 \mu\text{g}/\text{m}^3$ at one soil gas location (DCD-SG-02-12). Figure 5.2 shows the sampling locations with exceedances.

Since the maximum detected soil gas concentration for carbon tetrachloride, chloroform, and TCE exceeded their respective residential VI screening levels, a refined assessment of the vapor intrusion pathway using the Johnson and Ettinger model was conducted using site-specific inputs and attenuation factors. The results from the refined vapor intrusion assessment are discussed below in Section 6.3.2.

6.3 ESTIMATION OF CHEMICAL EXPOSURE

For residential and industrial receptors, it is not necessary to estimate exposures; i.e., dose estimates are not required. Instead, an exposure point concentration (EPC) is compared to chemical-specific screening levels. The screening levels used were the USEPA (2013a) RSLs and are shown in Appendix G. However, RSLs are not available for construction workers. Therefore, the following equations were used to estimate exposures for each exposure pathway.

Ingestion of Soil

Intake of COPCs via ingestion of soil for construction workers was estimated using the parameters and equations described in USEPA (1989, 2013a) guidance and the RAD (AQS, 2013). Potential exposure via incidental soil ingestion were estimated using the following equation:

$$\text{Intake} = \frac{C_{\text{soil}} \times \text{IR}_{\text{soil}} \times \text{EF} \times \text{ED} \times \text{FI} \times \text{CF}}{\text{BW} \times \text{AT} \times 365 \text{ days/year}}$$

where:

Intake	=	The administered dose (mg/kg-day)
C_{soil}	=	COPC concentration in soil (i.e., EPC) (mg/kg)
IR_{soil}	=	Soil ingestion rate (mg/day)
EF	=	Exposure frequency (days/year)
ED	=	Exposure duration (years)

1	FI	=	Fraction ingested (i.e., assumes 100-percent ingested) (unitless)
2	CF	=	Conversion factor (10^{-6} kg/mg)
3	BW	=	Body weight (kg)
4	AT	=	Averaging time (years)

5 The values for each exposure parameter used to evaluate construction workers at the site
6 are presented in Appendix G, Table G.4.

7 **Dermal Contact with Soil**

7 The dermally absorbed dose resulting from contact with contaminants in soil was
8 calculated following USEPA (1989, 2004a, 2013a) guidance and the RAD (AQS, 2013) using
9 the following equation:

$$10 \quad \text{Intake} = \frac{C_{\text{soil}} \times CF \times AF \times DAF \times EF \times ED \times ET \times SA}{BW \times AT \times 365 \text{ days/year}}$$

11 where:

12	Intake	=	Dermally absorbed dose (mg/kg-day);
13	C_{soil}	=	COPC concentration in soil (i.e., EPC) (mg/kg)
14	CF	=	Conversion factor (10^{-6} kg/mg)
15	AF	=	Soil-to-skin adherence factor (mg/cm ²)
16	DAF	=	Dermal absorption fraction (unitless)
17	EF	=	Exposure frequency (days/year)
18	ED	=	Exposure duration (years)
19	ET	=	Exposure time (fraction of exposure frequency in contact with
20			contaminated soil) (unitless)
21	SA	=	Skin surface area available for contact (cm ²)
22	BW	=	Body weight (kg)
23	AT	=	Averaging time (years)

24 The values for each exposure parameter used to evaluate construction workers at the site
25 are presented in Appendix G, Table G.4.

26 **Inhalation**

26 Current USEPA (1996, 2002a, 2004b, 2009) guidance does not recommend estimating
27 intakes (i.e., mg/kg-day) for the air inhalation pathway. Rather, risks and hazards were
28 determined by comparing estimated volatile/particulate air concentrations, adjusted for exposure

frequencies/durations/time, with inhalation toxicity values. Methods for estimating indoor air exposure concentrations via the USEPA (2004a) Johnson and Ettinger model and methods for estimating concentrations of COPCs volatilized and emitted from soil into outdoor air are described in Section 6.3.2.

6.3.1 Exposure Point Concentrations (EPCs)

An EPC is the concentration of a particular chemical in a particular environmental medium (e.g., soil), at the point of contact with the receptor. Exposure-point concentrations are intended to be representative of the concentrations of chemicals in a given medium to which a receptor may be chronically exposed at the site (i.e., the exposure point). For incidental ingestion and dermal contact with soils, the soil data collected at the site were used to calculate the EPCs, as described below. For the inhalation of dusts and VOCs, fate and transport models were used to estimate EPCs for the COPCs in air, as described in Section 6.3.2.

Hypothetical residents that may live on the site in the future are likely to live on lots that are a quarter of an acre or smaller. Therefore, residents are likely to be exposed to the COPCs in a rather small portion of the site. To account for this, the maximum detected concentration for each COPC was used as the EPC. Industrial and construction workers, however, are assumed to be exposed to soils across the entire site. Therefore, the 95-percent UCL was used as the EPC (USEPA 1989, 1992b, 2002b, 2007a) for industrial and construction workers. Under certain circumstances, the UCL may be greater than the maximum detected value. In these cases, the maximum detected value was used as the EPC instead (USEPA 1989, 1992b, 2002b). The EPCs are shown in Appendix G, Table G.1.

6.3.2 Fate and Transport Modeling

For direct contact (i.e., incidental ingestion and dermal contact), the soil measurements may be used directly. However, to estimate exposures to chemicals in dusts and volatiles that may migrate to the atmosphere, it is necessary to model the migration of chemicals to the atmosphere. This section describes the fate and transport models used to estimate EPCs for nonvolatiles in outdoor dusts and volatiles in air (outdoor and indoor).

Indoor Air

For the migration of volatiles to indoor air, the Johnson and Ettinger model (USEPA 2004b, DTSC 2005b) was used to estimate indoor air EPCs. The Johnson and Ettinger model

(USEPA, 2004) uses a one-dimensional analytical solution to simulate the convective and diffusive processes that drive vapor intrusion into buildings from subsurface sources. The model also accounts for the concentration, depth, and physical properties of each COPC, soil physical properties (i.e., geotechnical properties), and building characteristics. The model, including all equations, is shown in detail in the Johnson and Ettinger model user's guide (USEPA 2004b). The parameters used to model vapor intrusion at the site are discussed below.

With the exception of acetone and 1,3,5-trimethylbenzene, the maximum detected concentrations in soil gas were detected in the 12 ft bgs interval. It is hypothesized that the higher concentration of VOCs in deeper intervals may be due to entrapment of VOC vapors beneath plastic sheeting. Large amounts of plastic sheeting were observed throughout the landfill during the October 2012 test pit operations, and collectively, this plastic sheeting may be acting as an unintentional vapor barrier in the soil.

Per the RAD, (AQS, 2013), the maximum concentration regardless of depth was used as the source term in the Johnson and Ettinger model. All of the maximum detected concentrations were detected in the 12 ft interval with the exception of acetone and 1,3,5-trimethylbenzene (Table 5.2). For acetone and 1,3,5-trimethylbenzene, the maximum detected concentration from the 5 ft bgs interval was used as the source term in the Johnson and Ettinger model. However, for all of the analytes the depth of the soil gas source was assumed to be 12 ft bgs for soil gas (i.e., the depth that largely had the maximum concentrations detected). The chemical properties used in the model were taken from USEPA (2004) (Table G.3). In the model, generic soil properties were used and are presented in Appendix G, Table G.2. For residents and industrial workers, a generic 10m x 10m single-story slab-on-grade building was assumed to be present at the site using the building properties shown in Appendix G, Table G.2. The soil gas infiltration rate for a 10m x 10m building is assumed to be 5 L/min. The indoor-outdoor air exchange rate for residents was assumed to be 0.45/hr; i.e., the default exchange rate for residential buildings (USEPA, 2011). The indoor-outdoor air exchange rate for industrial workers was assumed to be 1.5/hr; i.e., the default exchange rate for industrial buildings (USEPA, 2011). The Johnson and Ettinger model spreadsheets are provided in Appendix G, Attachment G.2.

Outdoor Air

For construction workers, it is assumed that inhalation exposure to COPCs in soil can occur via: 1) inhalation of VOCs volatilized from soil into outdoor air; and 2) inhalation of

constituents adsorbed to suspended respirable particles in outdoor air. For the migration of volatiles (i.e., chemicals with a molecular weight less than 200 g/mole and a Henry's Law constant greater than 1×10^{-5} atm-m³/mole) in soils to the atmosphere air or outdoor air, USEPA's (1996, 2002a) volatilization factor (VF) model was used. The VF was used to estimate the concentrations of VOCs in outdoor as follows:

$$C_{air} = \frac{C_{soil}}{VF}$$

where:

C_{air} = COPC concentration in outdoor air (mg/m³)

C_{soil} = COPC EPC in soil (mg/kg)

VF = volatile emission factor (m³/kg)

The VF was calculated using physical properties of each COPC, soil physical properties (i.e., geotechnical properties), the area of the site, the exposure duration of the receptor, and the location of the site. The equation and parameter values used to calculate the VF is shown in Appendix G, Attachment G.4. The estimated outdoor air EPCs are shown in Appendix G, Table G.1.

Chemical concentrations in dust were estimated for the nonvolatile chemicals that can sorb to soils and become airborne dust through wind erosion. Receptors at the site may then be exposed to chemicals in dust through the inhalation of respirable dust. Respirable dust particles are composed of particulate matter 10 microns or less in diameter. The airborne fugitive dust EPCs were estimated as follows:

$$C_{air} = \frac{C_{soil}}{PEF}$$

where:

C_{air} = COPC concentration in airborne dust (mg/m³)

C_{soil} = COPC EPC in soil (mg/kg)

PEF = particulate emission factor (m³/kg)

The PEF was applied to all nonvolatiles detected in soils at the site. This includes all metals and SVOCs with a molecular weight less than 200 g/mole and a Henry's Law constant

less than 1×10^{-5} atm-m³/mole. The PEF used in this assessment was the default recommended in the RAD (AQS, 2013). The airborne PM₁₀ EPCs are shown in Appendix G, Table G.1.

6.4 TOXICITY ASSESSMENT

The toxicity assessment characterizes the relationship between the magnitude of exposure to a COPC and the nature and magnitude of adverse health effects that may result from such exposure. For risk assessment purposes, adverse health effects are classified into two broad categories: carcinogens and noncarcinogens. Toxicity values are generally developed based on the nonthreshold approach (i.e., any level of exposure results in increased risks) for carcinogenic effects and the threshold approach (i.e., exposures below the threshold do not result in increased risks) for noncarcinogenic effects. Toxicity values used in risk assessments may be based on epidemiological studies, short-term human studies, and subchronic or chronic animal studies. The toxicity values used here were taken from the USEPA (2013a) RSL tables, which were derived from the following hierarchy for toxicity sources (AQS, 2013):

1. USEPA's Integrated Risk Information System on-line database (USEPA, 2013a),
2. USEPA's Provisional Peer Reviewed Toxicity Values (PPRTVs),
3. Agency for Toxic Substances and Disease Registry minimal risk levels,
4. California Environmental Protection Agency Office of Environmental Health Hazard Assessment's Chronic Reference Exposure Levels and the Cancer Potency Values,
5. Appendix to certain PPRTV assessments, and
6. USEPA's Health Effects Assessment Tables (USEPA, 1997a).

6.4.1 Chemicals without Toxicity Values

For dimethylphthalate no toxicity data was available from the hierarchy of sources listed above. Further, no suitable surrogates were identified. Therefore, this analyte was not quantitatively evaluated in this risk assessment.

6.5 RISK CHARACTERIZATION

Separate procedures were used to estimate cancer and noncancer health effects. Also, separate procedures were used to estimate risks from exposures to soil (through incidental ingestion, dermal contact, and the inhalation of outdoor dusts) and from indirect exposures via

the inhalation of VOCs in air. The Johnson and Ettinger model was used to estimate the potential cancer and noncancer risks from indirect exposures via the inhalation of VOCs that have migrated to indoor air from soil gas (Appendix G, Attachment G.2). To estimate the potential cancer and noncancer risks from exposures to soil, the EPCs for each COPC were divided by the cancer and noncancer based USEPA (2013a) RSLs for each COPC, as follows:

$$\text{Cancer risk} = \frac{EPC}{SL_c} \times 10^{-6}$$

$$\text{Noncancer hazard quotient} = \frac{EPC}{SL_{nc}}$$

where:

EPC	=	exposure point concentration (mg/kg)
SL _c	=	cancer-based screening level (mg/kg)
SL _{nc}	=	noncancer-based screening level (mg/kg)

For construction workers, the following procedures were used to estimate cancer and noncancer health effects. For carcinogens, risks are estimated as the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen (i.e., incremental or excess individual lifetime cancer risk). Carcinogenic risk probabilities were estimated by multiplying the exposure level calculated for each exposure route by the corresponding cancer toxicity value (i.e., SF or URF) (USEPA 1989, 1996, 2004a, 2009) as follows:

$$\begin{aligned} \text{Risk}_{\text{oral}} &= \text{Intake}_{\text{oral}} \times \text{SF} \\ \text{Risk}_{\text{dermal}} &= \text{Intake}_{\text{dermal}} \times \text{SF}_d \\ \text{Risk}_{\text{inhalation}} &= \frac{C_{\text{air}} \times EF \times ED \times ET \times URF \times CF}{AT \times 365 \text{ days/year}} \end{aligned}$$

where:

Risk	=	Incremental or excess individual lifetime cancer risk for each COPC (unitless)
Intake _{oral,dermal}	=	Oral and dermal exposure for each COPC (mg/kg-day)
SF	=	Route and chemical specific slope factor ((mg/kg-day) ⁻¹)
SF _d	=	SF/OAF
OAF	=	Oral absorption factor (unitless)

1	C_{air}	=	COPC concentration in airborne dust derived by modeling the PEF
2			or COPC concentration in outdoor air derived by modeling the VF
3			(mg/m ³)
4	EF	=	Exposure frequency (days/year)
5	ED	=	Exposure duration (years)
6	ET	=	Exposure time; i.e., the fraction of the day spent at the site
7			(unitless)
8	URF	=	Chemical specific inhalation unit risk factor ((μg/m ³)-1)
9	CF	=	Conversion factor (1,000 μg/mg)
10	AT	=	Averaging time (years)

11 For exposure to noncarcinogens, adverse effects are not assumed to occur below a certain
 12 threshold (i.e., the RfD or RfC). The potential for adverse noncarcinogenic effects (i.e., the
 13 hazard quotient or HQ) was estimated by dividing the exposure level calculated for each
 14 exposure route by the corresponding noncancer toxicity value (i.e., RfD or RfC) (USEPA 1989,
 15 1996, 2004a, 2009) as follows:

$$\begin{aligned}
 16 \quad HQ_{oral} &= \frac{Intake_{oral}}{RfD} \\
 17 \quad HQ_{dermal} &= \frac{Intake_{dermal}}{RfD_d} \\
 18 \quad HQ_{inhalation} &= \frac{C_{air} \times EF \times ED \times ET}{RfC \times AT \times 365 \text{ days/year}}
 \end{aligned}$$

19 where:

20	HQ	=	Hazard quotient for each COPC (unitless)
21	$Intake_{oral,dermal}$	=	Oral and dermal exposure for each COPC (mg/kg-day)
22	RfD	=	Route and chemical reference dose (mg/kg-day)
23	RfDd	=	RfD x OAF
24	OAF	=	Oral absorption factor (unitless)
25	C_{air}	=	COPC concentration in airborne dust derived by modeling the PEF
26			or COPC concentration in outdoor air derived by modeling the VF
27			(mg/m ³)
28	EF	=	Exposure frequency (days/year)
29	ED	=	Exposure duration (years)
30	ET	=	Exposure time; i.e., the fraction of the day spent at the site
31			(unitless)
32	RfC	=	inhalation reference concentration (μg/m ³)
33	AT	=	Averaging time (years)

Risk probabilities are assumed to be additive for all COPCs. Therefore, the risks from exposures to soil and the inhalation of VOCs that have migrated to indoor air from soil gas were summed as an estimate of the total risks for each receptor at the site. The total excess cancer risk estimates are then compared to the point of departure of 10^{-6} (DSHW, 2011). Total risks greater than this threshold value indicate that exposure to the COPCs at the site may result in a non-negligible cancer risk. In general, total risks greater than 10^{-4} (e.g., 10^{-3} or 10^{-2}) require further action; risks between 10^{-6} and 10^{-4} are in the risk management range and require the stakeholders to discuss and decide whether the risk estimates are acceptable; and risks less than 10^{-6} (e.g., 10^{-7} and 10^{-8}) are acceptable.

After summing all of the hazard quotients for all COPCs for a receptor, the sum is then compared to the USEPA acceptable hazard level of 1. This summation is called a hazard index (HI). A hazard index of 1 is used as a benchmark level to indicate whether adverse health effects are likely to occur as a result of exposures to COPCs at the site. Hazard indexes greater than 1 indicate that adverse noncarcinogenic health effects may occur whereas, hazard indexes less than or equal to 1 indicate that adverse noncarcinogenic health effects are unlikely to occur.

6.5.1 Risks Estimates

Residents

Total excess cancer risks for assumed residential exposures to soil (through incidental ingestion, dermal contact, and the inhalation of outdoor dusts) and the inhalation in VOCs that have migrated to indoor air from soil gas were estimated using the maximum detected concentrations. This results in a total risk estimate of approximately 2.43×10^{-5} , which exceeds the point of departure of 1×10^{-6} but is within the risk management range of 1×10^{-6} to 1×10^{-4} (Appendix G, Table G.7). This risk estimate is almost entirely due to assumed exposures to benzo(a)pyrene in soils and assumed inhalation exposures to chloroform in indoor air from soil gas.

Assumed residential exposures resulted in a total HI of approximately 2.85 (Appendix G, Table G.7). A hazard index approximately greater than 1 indicates that adverse noncarcinogenic health effects are likely to occur.

Industrial Workers

Total excess cancer risks for assumed residential exposures to soil (through incidental ingestion, dermal contact, and the inhalation of outdoor dusts) and the inhalation in VOCs that

have migrated to indoor air from soil gas were estimated using the EPCs shown in Appendix G, Table G.1. This results in a total risk estimate of approximately 3.27×10^{-6} , which exceeds the point of departure of 1×10^{-6} but is within the risk management range of 1×10^{-6} to 1×10^{-4} (Appendix G, Table G.9). Assumed industrial exposures resulted in a total HI of 0.0924, which is below the benchmark level of concern for noncarcinogenic effects (Appendix G, Table G.9).

Construction Workers

Total excess cancer risks for assumed construction workers exposures to soil (through incidental ingestion of soil, dermal contact with soil, and the inhalation of dusts and volatiles in outdoor air) were estimated using the EPCs shown in Appendix G, Table G.1. This results in a total risk estimate of approximately 1.98×10^{-7} , below the point of departure of 1×10^{-6} (Appendix G, Table G.10). Assumed construction worker exposures resulted in a total HI of 0.383, which is below the benchmark level of concern for noncarcinogenic effects (Appendix G, Table G.10). Since construction workers primarily work outdoors, assumed exposures from the inhalation in VOCs that have migrated to indoor air from soil gas is an incomplete exposure pathway and therefore, and was not evaluated (AQS, 2013).

6.6 HRA UNCERTAINTY ANALYSIS

This section presents an evaluation of several potential sources of uncertainty in the risk estimates. Uncertainty may have been introduced into the risk calculations as a result of:

- Land use at the site
- Residential soil ingestion rates
- Using the maximum detected concentration as the EPC
- Chemicals without toxicity values

The most significant source of uncertainty in this risk assessment is the assumed land use at SWMU 28. Currently, there are no plans to redevelop SWMU 28 for residential land use. Thus, it is unlikely that residents would be present at the site.

The soil ingestion rates assumed here (i.e., 100 mg/day for adults and 200 mg/day for children) may overestimate the risks from assumed exposures at this site. The Exposure Factors Handbook (USEPA, 2011) recommends values of 50 mg/day for adults and 100 mg/day for

1 children. Thus, the soil ingestion rates assumed here are highly health-protective and may over
2 estimate the risks from incidental soil ingestion at the site.

3 To assess residential exposures to soils at the site, the maximum detected concentration
4 was used as the EPC for each COPC. Also, the maximum detected concentration was used and
5 as the source term concentration for the fate and transport modeling for residential and industrial
6 receptors. However, the maximum detected concentrations for all COPCs do not co-occur.
7 Therefore, this approach over-estimates even worst case exposure to soils and soil gas at the site.
8 However, this approach provides a health-protective assessment of residential and industrial
9 exposures at the site and ensures that the risks are not underestimated.

10 With the exception of acetone and 1,3,5-trimethylbenzene, the maximum detected
11 concentrations in soil gas were detected in the 12 ft bgs interval. As discussed in Section 6.3.2,
12 this is assumed to be due to entrapment of VOC vapors under the plastic sheeting, which is
13 potentially acting as an unintentional vapor barrier in the soil. However, there may be locations
14 in the landfill where the plastic barrier is not present and as such the risks may be
15 underestimated. However, based on field observations the plastic sheeting was prominent
16 throughout the entire landfill.

17 For some of the COPCs evaluated here, toxicity data for surrogates was used. The use of
18 surrogates may result in an over or underestimate of risks and hazards. Further action based on
19 the risk/hazard estimates for chemicals that are based on surrogates should not be conducted
20 without additional consultation with USEPA and DSHW.

21 Toxicity data were not available for dimethylphthalate. Additionally, an appropriate
22 surrogate was not available for this COPC and the potential for adverse health effects from
23 exposure to this chemical was not assessed. Uncertainty associated with the lack of toxicity data
24 for dimethylphthalate is not expected to be significant since compounds with known toxicity
25 values (i.e., benzo(a)pyrene and chloroform) contribute significantly to cumulative risk and
26 hazard estimates for SWMU 28.

27 Altogether, these potential sources of uncertainty in the risk estimates should be
28 considered in determining the recommended actions for the site. However, given the potential
29 sources of uncertainty discussed above and the conservative nature of the risk assessment
30 process, the risk estimates presented here are likely to have been overestimated.

6.7 ECOLOGICAL RISK ASSESSMENT

1 The objective of the ecological risk assessment (ERA) was to evaluate potential risks to
2 ecological receptors that may be exposed to site-related chemicals in soil from 0-10 ft bgs at
3 SWMU 28. This objective was accomplished by: 1) formulating the CSM and identifying
4 assessment endpoints; 2) analyzing ecological receptor exposures to, and the toxicity of, soil
5 contaminants detected at the site; and 3) characterizing the potential hazards to ecological
6 receptors.

7 The analysis and risk characterization results from the site-specific ERA will support a
8 risk-management decision regarding whether there is a need for a more detailed evaluation
9 through the next level of ERA or implementation of corrective measures (if required).

10 The site-specific ERA was conducted in two sequential assessment tiers. Tier 1 serves as
11 a screening-level assessment that uses site-specific data and conservative exposure assumptions
12 to identify preliminary chemicals of potential ecological concern (COPECs) that pose an
13 acceptable exposure situation and do not pose a hazard. Preliminary COPECs that do not pose a
14 hazard in the Tier-1 evaluation are eliminated from further assessment. Preliminary COPECs
15 that “fail” the Tier-1 evaluation (that is, indicate a potentially unacceptable hazard to a receptor)
16 are retained as “final COPECs” and are evaluated further in the Tier-2 Assessment. The Tier-2
17 assessment provides a more-refined analysis of potential effects on ecological receptor
18 populations by incorporating additional site-specific information and more-realistic exposure
19 assumptions. The Tier-1 and Tier-2 assessments are organized according to the following key
20 elements of an ERA, which are adapted from USEPA (1997b and 1998) guidance: problem
21 formulation, analysis, and risk characterization. The problem-formulation step is combined for
22 the Tier-1 and Tier-2 assessments, while the analysis and risk characterization steps are
23 evaluated separately.

6.7.1 Problem Formulation

24 The ERA problem formulation step included developing a CSM and defining the
25 assessment endpoints, ecological receptors, and contaminants to be evaluated at the site. A site-
26 specific CSM that identifies site-specific contaminant sources, affected media, representative
27 receptors (i.e., assessment endpoints), and exposure pathways is presented on Figure 6.2. The
28 assessment endpoints and representative receptors for use were defined in the Risk Assumptions

Document (AQS, 2013); the representative receptors include the deer mouse and horned lark populations, and the terrestrial plant community.

The preliminary COPECs identified for evaluation at SWMU 28 are listed in Appendix G, Tables G.1. The representative wildlife receptors and preliminary COPECs identified for SWMU 28 were quantitatively evaluated through the following Tier-1 analysis and risk characterization steps.

6.7.1.1 Potential Exposure Areas

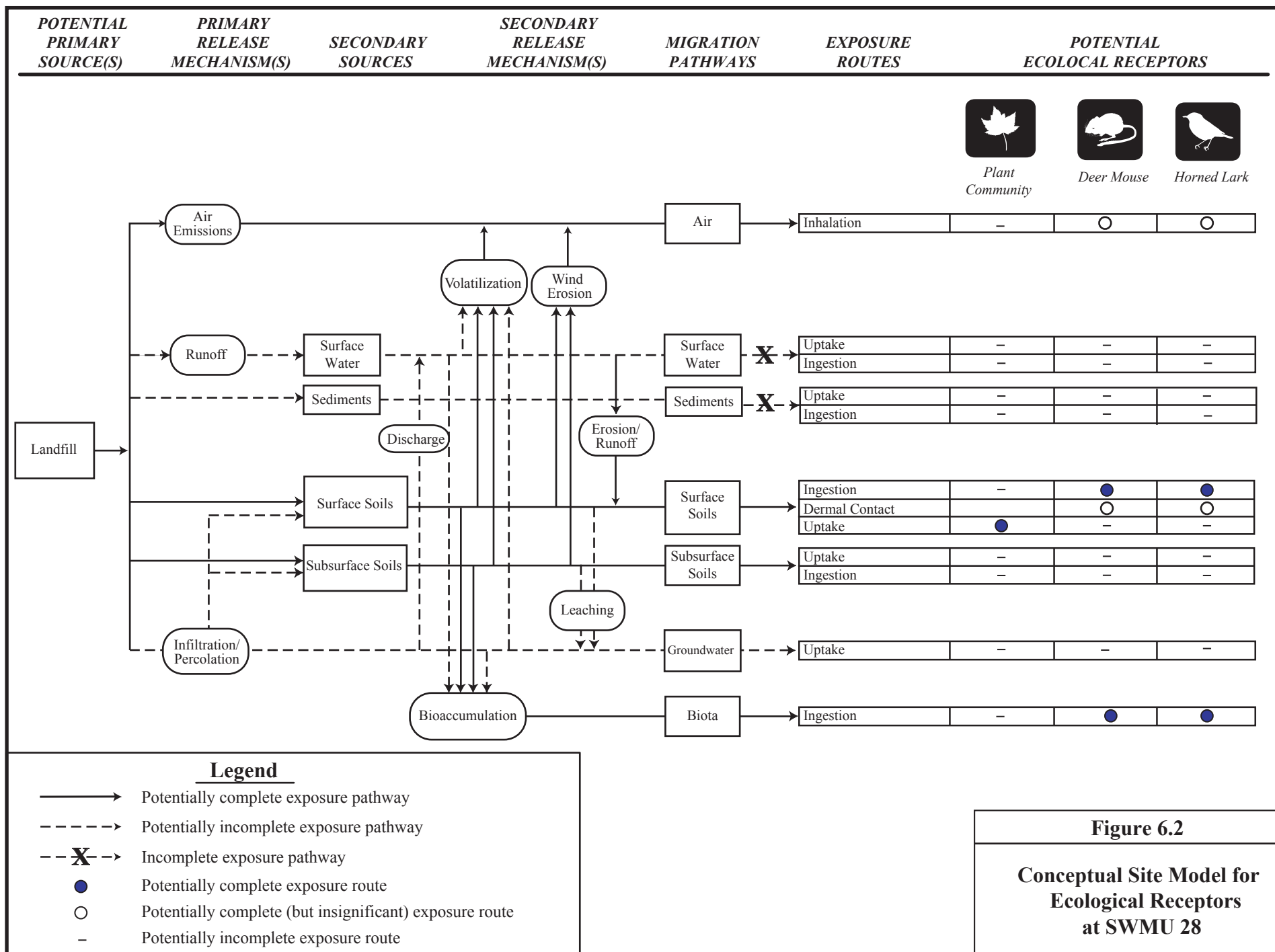
In order for a potential receptor population to exist, sites must contain open areas that would allow plant growth and suitable habitat for wildlife. The exposure area for the ERA incorporates the SWMU 28 inactive landfill. This exposure area covers approximately 0.3 acres. The site's affected area was adopted as the direct exposure area for potential ecological receptor contact with COPECs in surface and subsurface soil. The affected area was also used to define the exposure areas for indirect exposures to soil COPECs via ingestion of vegetation and prey.

6.7.1.2 Potential Receptors

Potential wildlife receptors evaluated were selected from the list of representative, facility-wide receptors presented in the RAD (AQS, 2013). Vegetation was considered a representative receptor for this site because primary productivity is a vital ecological component, and vegetation is an important component of habitat for wildlife receptors. No special-status species of wildlife or plants were identified at or near the site. The following were selected as representative receptors for evaluation in the ERA:

- Deer mouse population
- Horned lark population
- Terrestrial plant community

The animal receptors are non-domesticated wildlife that may reasonably be expected to occur at the SWMU 28 given the current and anticipated future site conditions. The plant community is an integral ecological component and serves as a potential conduit for exposures of herbivorous wildlife. When considered in conjunction with plants and invertebrates as biotransfer media, the selected wildlife receptors are representative of the food web in the area. Habitat requirements, dietary requirements, and behavioral traits for each of the representative wildlife receptors at TEAD-S are presented in the RAD (AQS, 2013).



6.7.1.3 Potential Exposure Pathways

1 An organism may be at-risk from a Tier 1 preliminary COPEC if there is a complete
2 exposure pathway between the Tier 1 preliminary COPEC source and the organism. The site has
3 resident plants, invertebrates, and animals, and provides potential foraging habitat for other
4 organisms. Soils are the only potentially contaminated media at the site; in addition, plants and
5 animals contacting the sediment may themselves serve as conduits for exposure of other
6 organisms to site-related chemicals via food-web transfers. Thus, organisms may be exposed to
7 Tier 1 preliminary COPECs through:

- 8 • Contact, ingestion, and inhalation of contaminants in soils;
- 9 • Ingestion of site-associated biota.

10 These exposure pathways form the basis for the assessment endpoints and the
11 specification of the CSM. There is no surface water on site; therefore, surface water exposure
12 pathways were considered insignificant and were not evaluated quantitatively in the ERA.

13 For the purpose of this assessment, exposures were evaluated for soil (e.g., terrestrial)
14 pathways. Terrestrial plants present at the site may be exposed to soil borne contaminants
15 through root contact, and some contaminants may be taken up into the vegetation and then be
16 consumed by herbivorous organisms. Similarly, terrestrial invertebrates potentially residing in
17 contaminated soils would contact and potentially incorporate these contaminants.

18 Wildlife exposures to chemicals in sediment and soil via inhalation (of volatiles or dust)
19 and dermal contact were not evaluated quantitatively in the ERA. Since there is a general
20 paucity of toxicological data for non-VOC compounds via inhalation and dermal-contact
21 exposure routes for free-ranging wildlife, hazards estimations for these routes would be non-
22 decisional due to a high degree of uncertainty (Sample et al., 1997). Birds and mammals,
23 however, might incidentally ingest sediment and soil during foraging, grooming, or burrowing
24 activities. Exposure to wildlife can occur via consumption of food items (e.g., plants,
25 invertebrates) that have accumulated Tier 1 preliminary COPECs from soil/sediment.

6.7.2 Tier-1 ERA Analysis and Risk Characterization

26 The Tier-1 ecological risk analysis and risk characterization are presented in this section.
27 The analysis step includes an assessment of the potential pathways for exposures of receptors to
28 preliminary COPECs and the potential toxicity of these preliminary COPECs to receptors. The

1 risk characterization step presents risk estimates and describes the risk results. Supporting tables
2 for wildlife receptors are provided in Appendix G (Tables G.11 through G.13).

6.7.2.1 Tier-1 Analysis

Tier-1 Exposure Assessment

3
4 Soil samples were collected within the affected area at SWMU 28. For the purposes of
5 the Tier-1 (screening-level) ERA, direct exposure pathways from these soil locations were
6 assumed to be complete for all representative species identified for the site (i.e., deer mouse,
7 horned lark, and the plant community). Therefore, exposures to maximum detected
8 concentrations of preliminary COPCs in the mixed-soil interval (0-10 ft bgs) were evaluated in
9 the Tier-1 ERA.

10 Tier-1 exposure doses for each wildlife receptor and preliminary COPEC were calculated
11 using the Tier-1 algorithms and species-specific body weights, dietary composition, and food-
12 ingestion rates presented in the RAD (AQS, 2013). The following conservative exposure
13 assumptions were used in estimating Tier-1 exposure doses for wildlife:

- 14 • One hundred-percent of the receptor's diet was assumed to contain the maximum
15 concentration of each preliminary COPEC detected in mixed soil (0-10 ft bgs).
- 16 • The minimum reported adult body weights and maximum total dietary intake rates for the
17 terrestrial wildlife receptor species evaluated were used to maximize estimated intakes.
- 18 • The receptor foraging ranges were assumed to be equal to the size of the affected area of
19 the SWMU 28 (i.e., the area use factor [AUF] was equal to 1.0), ensuring 100-percent of
20 the predicted exposure is from the affected area of the SWMU 28.
- 21 • The bioavailability of preliminary COPCs in soil is assumed to be 100-percent.

22 Tier-1 exposure doses are presented in the risk characterization section, where they are
23 also used in the estimation of potential ecological risk.

Tier-1 Effects Assessment

24 Chemical- and receptor-specific toxicity information was compiled from the literature
25 and other sources to characterize the potential adverse (i.e., toxic) ecological effects of
26 preliminary COPECs on the wildlife receptors. No-observed-adverse-effect-level (NOAEL)-
27 based toxicity reference values (TRVs) were derived for use as measures of effect and are
28 indicative of a dose at or below which an individual contaminant is unlikely to cause adverse

1 ecological effects (USEPA, 1997b). The purpose of using NOAEL-based TRVs is to indicate (by
2 comparison with an estimated exposure dose) those receptor and exposure-pathway
3 combinations that should be evaluated further. However, estimated exposure doses greater than
4 NOAEL-based TRVs do not indicate that adverse effect would be expected, because such TRVs
5 are, by definition, “no-effect” levels. Receptor-specific NOAEL-based TRVs for the preliminary
6 COPECs were derived for deer mice and horned larks (Appendix G, Tables G.11 and G.12,
7 respectively). For the plant-community receptor, there are limited data available with regards to
8 established toxicity benchmarks for plant receptors. Available phytotoxicity benchmarks were
9 derived from the Los Alamos National Laboratory (LANL, 2012), and are used herein.

6.7.2.2 Tier-1 Risk Characterization

10 Risk characterization includes processes of risk estimation and risk description. The risk
11 estimation process is the derivation of mathematical indices of the potential for ecological
12 hazard(s); the risk description highlights the significant results of the Tier-1 risk estimation for
13 wildlife receptors and provides the qualitative evaluation of the terrestrial-plant community as a
14 representative receptor.

Tier-1 Risk Estimation

15 The Tier-1 risk-estimation step involved comparing the screening-level exposure doses
16 (or concentrations) to the NOAEL-based TRVs in ratios referred to as screening-level hazard
17 quotients (SLHQs). These values represent conservative indicators of the potential that adverse
18 effects on the assessment endpoints could result from the estimated exposures to those receptors
19 (USEPA, 1998). NOAEL-based HQs should not be summed to generate HIs, as a summation of
20 HQs based on no-effect doses is a summation that does not result in a biologically meaningful
21 index.

22 Per USEPA (1997b), an SLHQ of one is considered to be the indicator threshold at or
23 below which the contaminant alone is unlikely to cause adverse ecological effects. Exposure
24 pathways for which the preliminary COPEC and receptor combination have an SLHQ value less
25 than or equal to one do not indicate a potential for adverse ecological effects, and are eliminated
26 from further evaluation. The combinations of chemical- and receptor-specific screening-level
27 exposure doses and TRVs used to calculate Tier-1 SLHQs, along with the resulting Tier-1
28 SLHQs, are presented in detail for the wildlife receptors in Appendix G, Tables G.11 - G.13.

Tier-1 Risk Description

As shown in Appendix G, Tables G.11 - G.13, some of the preliminary COPECs identified at SWMU 28 have SLHQs greater than one for one or more receptors, and were retained as final COPECs for evaluation in the Tier-2 assessment.

6.7.2.3 Tier-1 Conclusions: Final COPECs

Based on SLHQs greater than one, the following combinations of preliminary COPECs and receptors were retained for further evaluation in Tier 2 as the receptor-specific final COPECs:

- Deer mouse: antimony, nickel, selenium, and thallium
- Horned Lark: selenium and zinc
- Terrestrial plant community: antimony, selenium, thallium, and zinc

6.7.3 Tier-2 ERA Analysis and Risk Characterization

The Tier-2 analysis and Tier-2 risk characterization of the SWMU 28 ERA are presented in this section. Tier 2 provides a more refined analysis of potential effects on receptor populations from exposure to the final COPECs in soil by incorporating additional site-specific information, more-realistic exposure assumptions for the selected receptors, and effect-based TRVs for evaluating potential adverse effects in populations of receptors. Only those receptor-specific preliminary COPECs retained after the Tier-1 ERA were evaluated in the Tier-2 assessment.

6.7.3.1 Tier-2 Analysis

Tier-2 Exposure Assessment

Tier-2 exposure doses for each terrestrial wildlife receptor and final COPEC were calculated using the Tier-2 algorithms and species-specific body weights, dietary composition (including incidental soil ingestion), and food-ingestion rates detailed in the RAD (AQS, 2013). The Tier-2 exposure interval is refined and assumes that the deer mouse and horned lark would be exposed to surface soils (0-0.5 ft bgs). Deep-rooted terrestrial plants were assumed to be exposed to soils from 0-10 ft bgs. The Tier-2 exposure assumptions for terrestrial wildlife receptors included the use of average food ingestion rates and adult body weights. Additional computations were made in the Tier-2 exposure-dose estimates to account for accumulation of

final COPECs through the trophic levels utilized by the wildlife receptors. Tier-2 bioaccumulation factors were used to estimate exposure-point concentrations in representative food items (plants and invertebrates) for the receptors, as presented in Appendix G, Tables G.14 and G.15. The results of the Tier-2 exposure-dose calculations for wildlife receptors are presented in Appendix G, Tables G.16 - G.18, and were used in the risk characterization section to estimate potential ecological hazards.

Tier-2 Effects Assessment

The Tier-2 effects assessment for wildlife involved compiling available chemical- and receptor-specific toxicity information and deriving lowest-observed-adverse-effect-level (LOAEL)-based TRVs to supplement the NOAEL-based TRVs derived for Tier 1. LOAEL-based TRVs (that is, *effect*-based TRVs) are necessary for making inferences about the potential occurrence of adverse ecological effects; HQs derived using NOAEL-based TRVs cannot be used to indicate effect, because such TRVs are, by definition, “no-effect” levels. LOAEL-based TRVs calculated for deer mice and horned larks for all final COPECs are presented in Appendix G, Tables G.16 and G.27.

6.7.3.2 Tier-2 Risk Characterization

Tier-2 risk characterization includes processes of risk estimation (using LOAEL-based TRVs) and risk description. The risk estimation process is the derivation of mathematical indices (HQs and HIs); the risk description integrates the risk estimate values with other lines of evidence to provide context to the overall risk-assessment results.

Tier-2 Risk Estimation

The Tier-2 risk-estimation step involved comparing the Tier-2 exposure dose with LOAEL-based TRVs to develop LOAEL-based HQs. The chemical- and receptor-specific exposure doses and LOAEL-based TRVs used to calculate Tier-2 HQs, along with the resulting Tier-2 LOAEL-based HQs, are presented in Appendix G, Tables G.16 - G.18.

In the absence of special-status species as receptors, the focus of ecological risk assessment is on populations of receptor species. Adverse reproductive effects potentially caused by exposures to COPECs have, in the absence of overt acute toxicity, an obvious potential for affecting receptor populations over time. The effect-based (i.e., LOAEL-based) HQs can be summed to generate an HI for reproductive effects as a potential indicator of cumulative effects.

Tier-2 Risk Description

The risk description step involves summarizing and interpreting Tier-2 risk estimates in context with other available lines of evidence. Effect (LOAEL)-based HQs or HIs better indicate the potential for adverse effects on receptors because of the reliance on effect-based toxicological data. In addition, the consideration of Tier-2 LOAEL-based HQs is appropriate for SWMU 28 because the representative receptors are not endangered or threatened, and LOAELs better reflect potential population-level (rather than individual-organism) responses. The following guidelines were used for interpreting HQs or HIs:

- Adverse effects (to populations of receptors) are not expected for HQ or HI values less than one;
- A low potential for adverse effects may be indicated by HQ or HI values between one and 10; and
- A significant potential for adverse effects on ecological receptors and biological communities may be indicated by HQ or HI values greater than 10, particularly if they exceed a value of 100.

These initial categorizations were an approach for interpreting the mathematical results developed in quantitative ERAs. However, quantitative ERAs often produce HQs with mathematical values greatly exceeding one, but such a mathematical result does not necessarily indicate that adverse effects would be expected or would occur. An HQ is a derived value that integrates a host of assumptions about exposures and toxicity; if any of those assumptions do not completely apply to the site-specific conditions, then the mathematical HQ might not reflect a realistic likelihood of adverse effects to the assessment endpoint. In addition, there may be other site-specific ecological conditions (i.e., lines of evidence) which further support conclusions about the likely presence, or absence, of chemical hazards to ecological receptors. In fact, the norm (not the exception) may be that healthy, sustained populations of a variety of avian and mammalian wildlife are present at areas with a long history of contamination and with no documented “population-level” effects, despite various HQs “greater than one”. Nevertheless, the derivation of HQ values can be a tool useful during risk-management decision-making processes, provided their interpretation is placed in an ecological context.

The LOAEL-based Tier-2 HQ is less than one for estimated exposures of populations of deer mice to final COPECs. The LOAEL-based Tier-2 HQs are at or less than one for estimated

exposures of populations of horned larks to final COPECs. For the terrestrial plant community, the HQ is less than or equal to one. These results indicate an unlikely potential for final COPECs in soil to cause adverse ecological effects in mammalian and bird populations and terrestrial plant community that utilize SWMU 28.

In conclusion, concentrations of the final COPECs are not expected to pose unacceptable hazards to small mammal and bird populations that may utilize SWMU 28 during some of their foraging activities. Remedial strategies, therefore, do not need to further consider soils to ensure protection of ecological resources.

6.7.4 Uncertainties Associated with the Risk Assessment

This section presents an evaluation of several potential sources of uncertainty in the ERA risk estimates.

- The Tier-1 exposure estimates in the ERA incorporate an assumption of 100-percent bioavailability of the COPEC in the ingested medium. Actual absorbed doses are expected to be less than was estimated in this report, and risks to wildlife receptors are likely to have been overestimated.
- The RAD (AQS, 2013) indicates the terrestrial-plant community will be evaluated quantitatively if applicable toxicological benchmarks are available. There are available effect-concentrations for plants, but these have high uncertainty associated with their relevance to the plant community observed at SWMU 28. The majority of phytotoxicity studies used to derive the screening-benchmarks are based on root or shoot lengths, root or shoot weights, harvestable biomass, or other productivity-related indices relevant to agricultural crops (e.g., soybean, barley, radish, lettuce, wheat, rye, etc.). The productivity-related responses of agricultural crops grown in agricultural or greenhouse settings cannot be directly related to the high-desert conditions experienced by the plants growing on and near SWMU 28. The abiotic conditions (e.g., moisture regime, temperature, irradiance, climate, and site-specific soil conditions), the ecological characteristics of the TEAD-S vegetative communities (i.e., how the communities respond to and interact with their high-desert environment), and the species-specific characteristics of the specific plants growing at SWMU 28 (e.g., nutrient requirements, tolerance, and adaptability to soil conditions) are far too different from the collective conditions used in the studies for the benchmark derivation to give the benchmarks relevance to site-specific vegetation.
- Toxicity data (NOAELs/LOAELs) were not available for a few analytes. Additionally, appropriate surrogate were not available. Uncertainty associated with the lack of toxicity

1 data is not expected to be significant considering compounds with known degrees of
2 toxicity contribute significantly to hazard estimates.

6.8 RISK SUMMARY

3 The carcinogenic risks estimated for the three receptor groups assumed to be exposed to
4 soils, airborne dusts, and volatiles emitted to both indoor and outdoor air at the site are
5 summarized in Appendix G. The carcinogenic risks estimated for residents exceed the point of
6 departure of 1×10^{-6} . This risk estimate is almost entirely due to assumed exposures to
7 benzo(a)pyrene in soils and assumed inhalation exposures to chloroform in indoor air from soil
8 gas. However, the risk estimates for industrial and construction workers are within the USEPA
9 (1990) risk management range of 10^{-6} to 10^{-4} . The noncarcinogenic HI estimated for residents,
10 industrial workers, and construction workers are less than or equal to 1.0, the benchmark level of
11 concern for noncarcinogenic effects. Soil-to-groundwater analysis also indicates that future
12 impacts to groundwater from COPCs in soil are not expected. Finally, no chemicals of concern
13 were identified that may pose potential hazards to populations of ecological receptors at the site.

SECTION 7.0

RECOMMENDATIONS

According to Utah Administrative Code R315-101 (DSHW, 2011), the need for corrective action or continued management of a SWMU is based on the potential for unacceptable risks and hazards, using the following risk assessment criteria:

- The site qualifies for no further action (NFA) or risk-based closure if the carcinogenic risk is less than or equal to 1×10^{-6} , and the noncarcinogenic HI is less than or equal to 1 for a hypothetical residential scenario.
- If the carcinogenic risk is within risk management range of 1×10^{-6} to 1×10^{-4} and noncarcinogenic HI is less than or equal to 1 for industrial/actual use, then corrective measures may not be required per UAC R315-101 (DSHW, 2011).
- Corrective measures are required if the carcinogenic risk is greater than 1×10^{-4} , or the noncarcinogenic HI is greater than 1 for industrial/actual use.

SWMU 28 is an inactive landfill with debris observed between 3.5 ft bgs to 14 ft bgs. Buried debris was largely municipal, construction, and household wastes including foam padding, plastic sheeting, metal straps, and empty containers, pieces of wood, and rubber tire remnants. Native soils were encountered below the landfill debris zone, at approximately 12 to 15 ft bgs. Like all SWMUs at TEAD-S, SWMU 28 is classified as an industrial land use site and will remain so for the foreseeable future. A risk assessment was conducted using residential (hypothetical) and industrial (actual) land use exposure scenarios to determine potential risks and hazards to receptors (residents, industrial workers, and construction workers) from exposure to contaminants at SWMU 28. The carcinogenic risks estimated for residents exceed the point of departure of 1×10^{-6} . This risk estimate is almost entirely due to assumed exposures to benzo(a)pyrene in soils and assumed inhalation exposures to chloroform in indoor air from soil gas. However, the risk estimates for industrial and construction workers are within the USEPA (1990) risk management range of 10^{-6} to 10^{-4} . The noncarcinogenic HI estimated for residents, industrial workers, and construction workers are less than or equal to 1.0, the benchmark level of concern for noncarcinogenic effects.

SWMU 28 does not qualify for NFA or risk-based closure under the requirements of UAC R315-101-6, since residential cumulative cancer risk and noncancer HI estimates exceeded

1 residential target levels. However, risks and hazards associated with exposures to soil (through
2 incidental ingestion, dermal contact, and the inhalation of outdoor dusts) and the inhalation of
3 VOCs that have migrated to indoor air from soil gas are below industrial target levels that require
4 corrective action (i.e., HI greater than 1 and risk level greater than 1×10^{-4}). Additionally, soil-
5 to-groundwater analysis indicates that future impacts to groundwater from COPCs in soil are not
6 expected at SWMU 28. Also, no chemicals of concern were identified that may pose potential
7 hazards to populations of ecological receptors at the site.

8 Based on the results of the investigation, the following measures are recommended for
9 the SWMU 28 site:

- 10 • Corrective action is not required for the site because: 1) no industrial soil or
11 groundwater chemicals of concern were identified during the HRA; 2) there are no
12 expected future soil-to-groundwater impacts; and 3) there are no chemicals of
13 concern identified during the ERA. Therefore, industrial closure with post-closure
14 care is recommended. Future property development should be limited to industrial use
15 and land use controls are required to prevent residential use of the site.
- 16 • The SWMU 28 site occupies approximately 0.3 acres of land that is depressed
17 (sunken) approximately two to four feet below the surrounding ground surface. The
18 depressed area coincides with and overlies the zone of buried waste and debris. The
19 depression has the potential to collect and retain standing water from rain or snow
20 melt, increasing the likelihood that water will percolate and leach through the buried
21 waste zone. As part of the industrial closure, it is recommended that the landfill be
22 backfilled with clean soil and graded to surface or elevated slightly above surface to
23 prevent future ponding of water.
- 24 • Continued sampling of the three groundwater monitoring wells at SWMU 28 is not
25 warranted (S-32-90, S-33-90, and S-34-90). Soil-to-groundwater analysis indicates
26 that future impacts to groundwater from COPCs in soil are not expected. However,
27 annual water level measurements should be collected at these three groundwater
28 monitoring wells as part of the TEAD-S base wide water-level monitoring event.

SECTION 8.0

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